ANNALS
OF
The Entomological Society of America

Volume XXII JUNE, 1929 Number 2

COCOON-MAKING BY THE TARANTULA.*

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Cocooning of spiders has been observed and described for various species. H. E. Ewing has published a detailed illustrated account dealing with the house spider. Scheffer has recorded observations dealing with a number of species. Other writers such as Emerton, Savory, Pierre Bonnett, T. H. Montgomery, and others have made contributions to this subject. Regarding the cocoon-making by tarantulas there is, so far as I know, very little in the literature.

The tarantula, *Eurypelma californica* Ausserer, that is common in many parts of Arkansas as well as Texas and New Mexico, mates some time during the latter part of September or during October. In the following summer, from June to August, the females deposit the eggs in cocoons about as large as a black walnut without the hull. The earliest record of a cocoon that I have is June 7. Five cocoons were found to contain 1,018, 930, 787, 693, and 631 eggs respectively.

Although tarantulas do well in captivity (one of mine was taken in the spring of 1919 and as yet shows no decline in vigor), and mate readily during the season; they do not reproduce, presumably for want of some elements in the diet. Thus in order to observe the making of the cocoon, females that were obviously heavy with eggs were brought into the laboratory. During the summer of 1928 I secured two such females and succeeded in observing the entire process. When the

* Research Paper No. 134, Journal Series, University of Arkansas.

first female put on her performance I did not dare to take any pictures because of the inevitable disturbance that would accompany it. The second female was placed in a fairly large battery jar, seven-and-a-half inches in diameter, containing a layer of dirt covered over with fine black cinders. When she proceeded to make the cocoon, her amiable disposition made possible a number of time exposures, six of which are used to illustrate this paper.

Tarantula No. 1 was in a battery jar six inches in diameter and nine inches deep, containing one or two inches of soil. On June 30 she began spinning at about 7:45 A. M. At first she left a bare area on which she stood and spun all around herself. Then she began to move about and covered half of the soil surface as well as the wall to a height of about four inches. The finished product was a good-looking cradle, stretched over half of the soil, sloping up at the ends and equipped with a wall, about one-fourth inch high, along the straight side. This wall, as soon became evident, was intended to hold the egg mass more or less together.

In making this cradle, the tarantula worked very steadily, moving the abdomen from side to side so that the spinnerets would go from under one hind leg to under the other hind leg. In going over this stretch, approximately three inches, the spinnerets would touch the base about four times. When working on the sides she would stand nearly erect on her front legs, reaching about four inches up on the wall. She would rest every three or five minutes, but only for a very short period, from five to ten seconds. When the cradle was nearly done the rests became somewhat longer.

At 5:15, i. e. after nine-and-a-half hours of spinning, she considered the task finished. Assuming a position in which the abdomen was practically resting on the sheet of silk, and the anterior part of the cephalothorax well above it, she proceeded to deposit the eggs. These were in a liquid that gave the mass a light yellowish color. Egg laying required seventeen minutes. Unfortunately the wall that was to retain the eggs failed to do so, a part of the egg mass overflowed and became quite puzzling to the tarantula.

Immediately after egg-laying was finished she proceeded to cover the eggs with another layer of silk. For a time she spun mostly over the eggs, but later she spun over almost the entire

cradle. After spinning steadily for two hours and two minutes, allowing only short rests, as before; she began to pull down one end of the sheet, and then began to spin again. This alternating of spinning and tearing down (a sort of dove-tailing of the two phases in the performance) went on for an hour and twenty-three minutes.

Then the tarantula proceeded to pull the sheet from off the wall of the jar, using her palpi as well as the fangs. When the sheet was completely on the soil, she pulled up and back the edges and pressed them down with the weight of her body. Finally this was but a turning over on the edge and pressing down of the silken bag. In this part of the performance the tarantula became very deliberate, at first she would spend from twenty to thirty seconds resting on the cocoon, then longer, so that by 11:00 P. M. she spent from three to five minutes resting on the cocoon after turning it.

Tarantula No. 2 made her cocoon on July 8. When first observed, 8:15 A. M. she had almost finished the cradle, having presumably begun it about midnight. Egg-laying began at 8:47 and was finished in fifteen minutes. For an hour and forty-eight minutes she spun over the eggs and the cradle; an hour and twelve minutes was devoted in part to spinning and in part to pulling down the sheet. At 12:06 she proceeded in earnest with the shaping of the cocoon. She behaved in this just as already described for Tarantula No. 1. At 4:30 when I left her, she was devoting almost all the time to resting on the cocoon.

Tarantula No. 2 differed from No. 1 in that she made somewhat more rapid progress in the spinning. A more important difference was that instead of building a low silken wall she threw up a low earthen barrier, about one-fourth inch high, and about an inch wide. It answered the purpose well for the egg mass remained in the space intended for it (see Plate I).

The cocoons made in the laboratory jars are not as well constructed as the ones found out of doors. Some of these are apparently made under stones where the tarantula digs out a cavity sufficiently large for such operations. Many of the cocoons are apparently made in holes in which the tarantulas live. How they are able to do this in a space no larger than about one-and-a-half inches in diameter is not easily understood. It is possible that before making the cocoon the taran-

tula enlarges the base of her burrow, but I have seen no evidence of this.

After the cocoon has been made the tarantula stands guard over it, and on sunny days rolls it to the entrance of the burrow. From numerous failures in the laboratory, I have learned that the eggs require a good deal of sunlight. It seems that too much sunlight, or perhaps heat, will also prevent hatching.

At the end of a rainy and cool summer, I found several cocoons near tarantula holes that had apparently been abandoned by their owners. Presumably the cool and cloudy weather had delayed emergence of the spiders so long that the mothers had abandoned all hope. Two of these when taken in later produced a large number of young.

Since the young after hatching remain in the cocoon for some time, till they are ready to go through the first molt, the time required for hatching is not easily determined. And since cocoons made in the laboratory, or brought in when but very recently made, fail to produce any young; the time required for hatching and completion of the first instar can be no more than estimated. The earliest emergence observed is July 31, and the latest September 4. A cocoon brought in on July 27 produced young on September 4.

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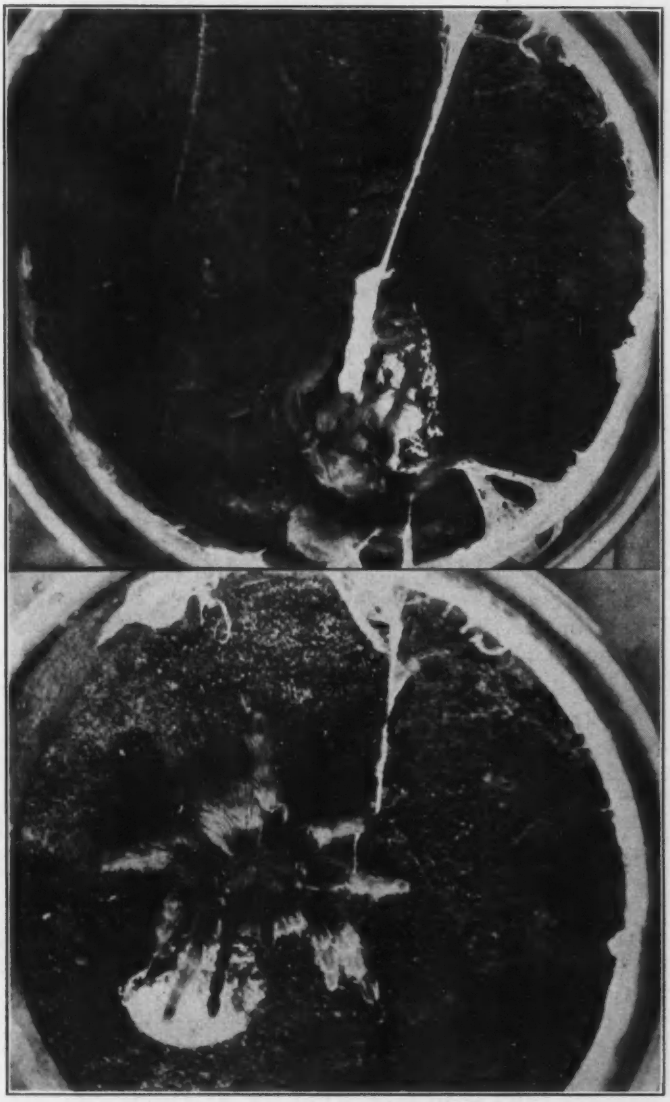
Above: Just before egg-laying. Note distended abdomen.
Below: Egg mass. Note much reduced abdomen.

Above: Starting to tear down cradle. No trace can be seen of egg mass.
Below: A later stage in tearing down.



Above: Cocoon has begun to take shape.
Below: Cocoon about finished, fore legs raised in attitude of defense. Note thin silken strand allowed to remain, as a guide to locate cocoon.

VARIATION AND CORRELATION ON THE LEGS OF THE HONEYBEE.

V. S. DAKESSIAN.

Although much work has been done on the variability of the different appendages of the honeybee and other social insects, within the last few years Russian investigators have revived special interest in this work from a somewhat different angle with different races of bees of different localities in Russia, and more recently in other countries of Europe and this country.

Works of Casteel and Phillips (1903), Kellogg and Bell (1904), Bachmetjew (1909), and many others, and recently of Phillips (1928), are chiefly on the variability of the different parts of the wings of different castes of the honeybee. The work of Russians, especially those of Alpatov (1925) and Alpatov and Tjunin (1925) are chiefly devoted to the difference in length and variability of the tongues of honeybees of different races and from different localities. Some of the works of Alpatov have been published and others are in process of publication, while still others are in preparation. It is unnecessary to review the literature on this subject here, since Phillips (1928), under whose direction this work was done, has prepared a paper on "The Variation and Correlation in the Appendages of the Honeybee" where extensive literature has been cited and reviewed. This work of Doctor Phillips will be published as a Memoir at the Cornell University Agricultural Experiment Station.

The legs of the honeybee, especially those of the workers are highly specialized for use of various functions other than locomotion. Without going into the details of the functions of different legs it may be said that little, if any, work has been done on the variation and correlation in the different segments of the legs of the honeybee. This work was therefore done in order to determine the variations and such correlations as may exist and to throw some light on the growth of the various parts of the legs in their relation to each other. The writer wishes to express his thanks to Dr. E. F. Phillips for his permission to use his manuscript and for his encouragement

at the beginning of the work, and also to Professor W. W. Alpatov for his valuable suggestions in preparing the legs for measurement.

Source of Material.—The individuals used in this work were taken from one colony of Italian bees in the apiary of Cornell University, at the middle of the day on July 6, 1927, and included both young and old bees. No drones were included and nothing was specifically known of the history of the colony from which the bees were taken at random.

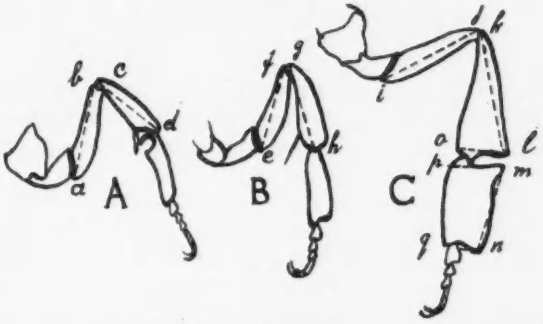


Fig. 1. Legs of the honeybee. Dotted lines show the points and the direction of the measurements.

Methods and Measurements.—The legs of bees are covered with heavy hairs and all the joints of the leg are heavily pigmented which makes accurate measurements difficult. To overcome this difficulty the bees were boiled in caustic potash until sufficient decoloration took place to make the distinction of definite points on the segments possible and to clarify the places where measurements could be made. While decoloring, it was noticed that the color of the upper segments of the legs, the coxa and trochanter, were much more heavily pigmented than the distal segments. Because of this and because of the irregularities of these segments no measurements were made of the coxa and trochanter. It was also noticed that the first and second legs are more heavily pigmented than the third legs, the tarsal segments of the third legs being least heavily pigmented and most easily bleached.

The points where the measurements were made on different legs are shown in Fig. 1. The measurements made on the

first, A, legs are only femur *a-b*, and tibia *c-d*. On the second, B, legs also femur *e-f* and tibia *g-h*. The first tarsal joints of these legs are covered with heavy hairs, and the tibia overlapping the first tarsal joint makes accurate measurement impossible. The measurements made on the third C, legs are the femur *i-j*, tibia *k-l*, the first tarsal segment *m-n*, the lower width of the tibia *o-l*, the upper *p-m* and the lower *q-n* width of the first tarsal segment.

The bees were preserved in 95% alcohol and those to be mounted were first brought to tap water and then mounted on slides in glycerin. This method saves considerable time and can be recommended for temporary work.

The legs of each bee were mounted separately and numbered in order to make correlations possible and to note the individual variations and the correlations that may exist between the segments of the legs of the same bee.

The method of measurement is partly that described by Phillips (1928). In order to reduce inaccuracies the microscope and the camera lucida were so arranged as to give a magnification of 50 diameters at table level. The ocular and the objective remained unchanged throughout the work and the tube of the microscope was fastened securely to prevent change. At the beginning it was found that the point and the direction of the measurement made on the reflected field made considerable difference in measurements. In order to avoid this inaccuracy, all measurements were made from one point on a straight line. The one end of the segment to be measured was brought to a definite point and the other end on the same straight line on which the fixed point was marked. Measurements were made on 200 individuals. All calculations were made by the usual biometric methods.

Variations.—From the data presented in Table I it is seen that the variation of the means, standard deviation and coefficient of variability of the bilateral symmetries is insignificant, in most cases being less than the probable error. This indicates that the size of the symmetrical segments are almost identical.

The coefficient of variability of the different segments are rather interesting. In all cases, except those of the width measurements, the coefficient of variability is smaller in the legs than in the other appendages except the tongue length, and

length and width of the head of which extensive data from different sources are given by Phillips (1928, Tables VIII, X and XI). Phillips finds similar variation in the vein *m* (right 2.5939 ± 0.055; left 2.5734 ± 0.055) of the worker as it is found in the first tarsus of the third legs (right 2.5218 ± .0850, left 2.5927 ± .0874). For the same segment of the larger drones, Phillips finds 3.8412 ± .082 variation. This points out the accuracy of the conclusion reached by the same

TABLE I.

THE VARIABILITY OF PARTS MEASURED.

CHARACTERS	MEAN × 50	STANDARD DEVIATION	COEFFICIENT OF VARIATION
1st tarsal joint, left 3rd leg	106.040 ± .1311	2.7493 ± .0927	2.5927 ± .0874
1st tarsal joint, *right* 3rd leg	106.085 ± .1276	2.6752 ± .0902	2.5218 ± .0850
Tibia, left 3rd leg	172.620 ± .1378	2.8889 ± .0974	1.6736 ± .0564
Tibia, *right* 3rd leg	172.710 ± .0144	3.0110 ± .1015	1.7434 ± .0588
Femur, left 3rd leg	142.805 ± .1215	2.5470 ± .0859	1.7836 ± .0602
Femur, *right* 3rd leg	142.850 ± .1155	2.4223 ± .0817	1.6927 ± .0572
Tibia, left 2nd leg	108.450 ± .1085	2.2754 ± .0767	2.0981 ± .0708
Tibia, *right* 2nd leg	108.395 ± .1140	2.3914 ± .0806	2.2062 ± .0744
Femur, left 2nd leg	123.060 ± .1228	2.5742 ± .0868	2.0918 ± .0705
Femur, *right* 2nd leg	122.810 ± .1281	2.6859 ± .0906	2.1870 ± .0738
Tibia, left 1st leg	96.270 ± .1046	2.1925 ± .0739	2.2774 ± .0768
Tibia, *right* 1st leg	96.075 ± .1048	2.1976 ± .0741	2.2714 ± .0766
Femur, left 1st leg	114.410 ± .1108	2.3242 ± .0784	2.0315 ± .0685
Femur, *right* 1st leg	114.435 ± .1159	2.4302 ± .0820	2.1237 ± .0716
Lower width, 1st tarsal joint, left 3rd leg	35.540 ± .0721	1.1527 ± .0510	4.2563 ± .1435
Upper width, 1st tarsal joint, left 3rd leg	58.045 ± .0935	1.9604 ± .0661	3.3774 ± .1139
Lower width Tibia, left 3rd leg	68.530 ± .0999	2.0950 ± .0707	3.4611 ± .1167

and other authors that drones are more variable than the workers.

Among the different segments of the legs the femur and tibia of the third legs are less variable, the degree of variability being similar to those of the variability of the tongues of Tula bees, which seem to be the least variable, (Phillips 1928, Table VIII) and those of the width of head of bees of various races (Phillips 1928, Table X). The variability of the similar segments of the other legs are somewhat greater than those of the third legs with rather insignificant difference in all cases.

Among the segments measured, the first tarsal joints of the third legs show greater variability. It is interesting to note that the segments vary more in their width than in their length.

Schneider and Dunn (1924) find about three times more variation in the tibia (4.398 ± .113) and femur (4.326 ± .112) of the White Leghorn fowl than it is found in the tibia and femur of the bee. Castle (1916) finds 2.524 coefficient of variability in inbred race B. guinea-pigs.

Correlation.—In Table II are given the values of the coefficient of correlations between different segments. In all cases correlations between symmetrical segments are higher than those between non-symmetrical segments. Similar correlation is found by Phillips (1928) for other parts of the honeybee, by Clawson (1905) in crayfish, by Lewenz and Whitely (1901-1902) in the hands of men. The highest correlation is found between the first tarsal segment of the third legs .9486 ± .0048. On the same legs the correlation between the tibia .9404 ± .0055 is slightly greater than between the femur .9256 ± .0068. In all cases however, the difference is insignificant. The reverse is true for the first and second legs where the correlation is higher between the femur than it is between the tibia.

The correlation between the first tarsal joint and the tibia of the third leg is greater (.7391 ± .0216) than that between the first tarsal joint and femur of the same leg. This brings out the conclusion arrived by Lewenz and Whitely that "There is 'rule of neighborhood,' i. e., any bone is more closely correlated with a second of the same series than with any other from which it is separated by that second."

The correlation between the femur of the first legs and between the femur of the second legs is almost identical (.8652 ± .0120 and .8622 ± .0122 respectively). However, the correlation between the tibia of the second legs is somewhat greater (.8054 ± .0168) than between the tibia of the first legs (.7897 ± .0180).

The correlation between the tibia and femur of symmetrical legs is greater on the third leg (.7333 ± .0220 than it is on the other two pairs of legs, it being slightly larger in the first leg (.6327 ± .0286) than in the second leg (.6040 ± .0303).

Castle (1914) finds greater correlation (.858) between the femur and tibia of rabbits than is found in the honeybee. In a later work (1922) again on rabbits he finds still greater

correlation (.927 ± .005). Schneider and Dunn (1924) also find greater correlation (.928 ± .005), their figures being identical with Castle's later work (1922).

The tibia of the third leg shows greater correlation with the tibia of the second leg (.5235 ± .0346) than it shows with the tibia of the first leg (.4898 ± .0363). The same is true for the femur of the third leg with the femur of the first and second

TABLE II.

CORRELATION BETWEEN THE VARIOUS SEGMENTS MEASURED.

CHARACTERS	COEFFICIENT OF CORRELATION
Bilateral symmetry, 1st tarsal joint, 3rd leg	.9486 ± .0048
1st tarsal joint and tibia, left 3rd leg	.7391 ± .0216
1st tarsal joint and femur, left 3rd leg	.6373 ± .0283
Length and lower width, 1st tarsal joint, left 3rd leg	.0621 ± .0475
Length and upper width, 1st tarsal joint, left 3rd leg	.2409 ± .0449
Bilateral symmetry, tibia, 3rd leg	.9404 ± .0055
Tibia and femur, 3rd left leg	.7333 ± .0220
Tibia and lower width, 3rd left leg	.3844 ± .0406
Tibia, left 3rd leg, tibia, left 2nd leg	.5235 ± .0346
Tibia, left 3rd leg, tibia, left 1st leg	.4898 ± .0363
Bilateral symmetry, femur, 3rd leg	.9256 ± .0068
Femur, left 3rd leg, tibia, left 2nd leg	.7369 ± .0218
Femur, left 3rd leg, tibia, left 1st leg	.6656 ± .0266
Bilateral symmetry, tibia, 2nd leg	.8054 ± .0168
Tibia, left 2nd leg, tibia, left 1st leg	.6973 ± .0245
Tibia and femur, left 2nd leg	.6040 ± .0303
Bilateral symmetry, femur, 2nd leg	.8622 ± .0122
Femur, left 2nd leg, femur, left 1st leg	.7163 ± .0232
Bilateral symmetry, tibia, 1st leg	.7897 ± .0180
Tibia and femur, left 1st leg	.6327 ± .0286
Bilateral symmetry, femur, 1st leg	.8652 ± .0120

legs, but the correlation is higher between the femur of different legs than it is between the tibia of the same legs.

It is rather interesting to note the correlation between the length and the width of the segments. The correlation between the length of first tarsal joint of the hind leg and the lower width of the same joint is only .0621 ± .0475, almost equal to its probable error. Of the upper width it is .2409 ± .0449. The correlation between the length of the tibia and lower width of the same joint of the third leg is only .3844 ± .0406, indicating that there is little correlation between the width and length of the segments, and that it is insignificant.

Conclusion.—Considering first the variability of the different segments of the different legs of the honeybee it is found that the first tarsal joint of the third leg is more variable than any of the other joints. The least variable segments are the tibia and femur of the third leg. The variability of the femur and tibia of the first and second legs are almost the same. The width of the segments measured are more variable than the length of any segment.

The variability of the segments of the legs of the honeybee is less than the variability of the different parts of the wing and still less than it is found in the leg joints of other animals.

The highest correlation is found between the bilaterally symmetrical joints. Taking each separately, the correlation between the segments of the third legs is higher than between the similar segments of the first and second legs.

Correlation between the segments of one leg is higher than the correlation between the similar segments of different legs.

There is no correlation between the length and width of the same segments.

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ON A COLLECTION OF GRYLLACRIDS AND TETTIGONIIDS (ORTHOPTERA), CHIEFLY JAVANESE.

H. H. KARNY,
Buitenzorg, Dutch East Indies.

Some of the determinations in a recent paper* appeared to me as somewhat doubtful, apparently due to insufficient material for comparison. Being especially interested in the two groups here treated, having worked on the Malayan forms of them for seven years and studied the types of most of the described species in European collections, I wrote to the author of the paper, who kindly loaned me the material discussed in the present article.

Family GRYLLACRIDÆ.

As I have shown in 1910 (SCHULTZE, Zool. Anthrop. Ergeb. Forsch. westl. u. zentr. Sudafrika; IV, 1, p. 35), it is quite impossible to retain the "Stenopelmatidæ" and "Gryllacridæ" of BRUNNER as mere subfamilies of Tettigoniidæ, and they must constitute together a separate family, the Gryllacridæ (s. l.), which must be regarded of the same rank as the Tettigoniidæ. A. GRIFFINI, the only specialist of Gryllacridæ at that time, has accepted entirely my point of view, when he says (Riv. mens. Sci. Nat. "Natura," II, p. 29; 1911): "Invece gli Stenopelmatidi vanno piuttosto uniti ai Grillacridi che sono le forme maggiormente primitive degli Ortotteri Saltatori, ed i Grillidi sono piu prossimi a questi che non gli altri gruppi." Nevertheless, most of recent authors have retained them as subfamilies of Tettigoniids, without giving any reason for not accepting GRIFFINI's and my system. I must suppose, therefore, they have apparently overlooked the literature cited above.

*1927. Caudell, A. N. Proc. U. S. Nat. Museum, Vol. LXXI, Article 3; 42 pages, 4 figs.

Subfamily GRYLLACRINÆ.

Gryllacris africana Brunner v. W.

1 ♂, Togo, Misahohe, 1894, E. BAUMANN S.—1 ♀, S. Kamerun, Lolodorf, L. CONRADT S.

Both specimens in every respect quite typical. Venation, type I, as described for this species in my revision of the Gryllacrids of Vienna Museum (now in press). Only a few aberrations in the number of branches may be noticed, viz.: Right tegmen of ♀ with six precostals. Radial vein on right tegmen of ♂ divided apically into five branches. On left tegmen of ♀ the posterior branch of the cubitus is forked,

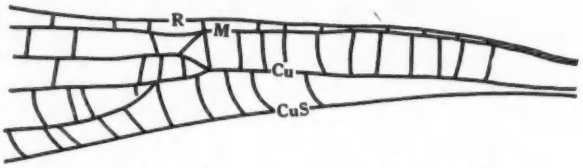


FIG. 1. *Gryllacris africana*, ♀. Basal area of left tegmen.

instead of the fore branch, which remains simple throughout on this tegmen (Fig. 1). Right hind wing of ♀ with radial vein five-branched.

Gryllacris translucens Serville.

1839. SERVILLE, Hist. Nat. Ins. Orth., p. 394, (*translucens*), (Java).
1860. GERSTAECKER, Arch. f. Nat., xxvi, p. 271, (*amplipennis*), (Brit. India).
1922. HEBARD, Proc. Ac. Nat. Sci. Philad., lxxiv, p. 276 (*vitrea*), (Borneo).
1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 28, (*tibialis*, nec SERVILLE), (Java).

Though I have not seen HEBARD'S type specimen of his *vitrea*, there can be no doubt from his accurate description that *vitrea* must be regarded as a synonym of *translucens*. This species was not yet recorded from Borneo, but I have seen in the Vienna Museum Bornean specimens which agree in every respect fully with the Javanese ones.

The specimens mentioned by CAUDELL as *tibialis* are now before me. They are typical *translucens* without any black color on tibiæ. *Gr. tibialis* does not occur in Western Java, so far as known; at least, in the neighborhood of Buitenzorg, I could never get that species amongst some hundreds *Gryllacris* specimens, whilst it is quite common in Central Java.

1 ♂, Mt. Salak, Java, BRYANT & PALMER Coll.—1 ♀, same collectors, Buitenzorg, Java, iv, '09.—1 juv. ♀, same collectors and locality, iii, '09.—1 juv. ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

All specimens quite normal and typical. The juv. ♀ from BRYANT & PALMER Coll. resembles, however, by the shape of ovipositor a fully-grown *Neanias;* the ovipositor being strongly curved, but not upwards and forwards against the abdominal tergites as usual in immature specimens, but the distal portion directed upwards and backwards. Nevertheless, there can be no doubt that it belongs also to *translucens*, as the larval wing-pads are very distinct, even longer than the pronotum.

Venation of the adult specimens quite normal. Type I, Radial vein of tegmina four- to seven-branched. On right tegmen of the ♂ before me the fore branch of the cubital vein is simple, whilst the hind branch is furcate; this represents, therefore, the same abnormity as figured above for *africana* (Fig. 1), but the bifurcation of hind branch placed somewhat more distad in *translucens* than in *africana*. Radial sector of hind wing three-branched.

Gryllacris melanocrania n. sp. (Plate I, Fig. 4).

1 ♂ (Holotype), Mokanshan, China, from N. GIST GEE. 1 ♀ (Allotype), Soochow, China, N. GIST GEE coll.

	Length of Body	*Pron.*	*Tegmen*	*Fore Fem.*	*Hind Fem.*	*Ovipos.*
♂	24'5 mm.	6'5 mm.	29 mm.	9'4 mm.	17 mm.	
♀	27 mm.	7'3 mm.	±30 mm.	11'3 mm.	19'5 mm.	25 mm.

Quite near to *Gr. humberti* GRIFFINI and *nigromarginata* KARNY, in size, agreeing better with the latter than with the former. General color cinnamon-buff, with head partly black and pronotum black margined.

Head a little wider than pronotum, subglobose. Occiput, vertex (excl. fastigium verticis), genæ, mandibles and labrum (excl. its extreme basal part) shining black, this color overreaching in front subocular sulci a little mesad. A narrow median line on occiput and its hind margin of body color. No ocellar spots. Antennal scrobes not margined with black. Basal segment of antenna strongly darkened, the following ones shining black, from about the 10th to 15th becoming gradually paler, rest of antennæ of body color. Suture between fastigium verticis and frontis concolorous, not at all blackish. Eyes yellowish or reddish brown.

Color of pronotum quite as in ***nigromarginata***, but no median pale length line on metazona. Fore margin of the disc a very little produced in the middle. Median sulcus of mesozona very feeble, metazona with a slight median keel.

Tegmina: Three simple precostals (♂) or the last bifurcate near base (♀). Costal vein simple (♀) or with two oblique anterior branches (♂), reaching the fore margin somewhat before (♀) or behind the apical third. Radial vein three-branched before the end, the branches oblique, distant from another (Fig. 2). Radial sector arising from radial stem before the middle, four-branched. Medial vein with a short, oblique cross vein against the cubital fore-branch near its base, otherwise simple. Cubital vein free, bifurcate at about the end of basal third. (Hind wings not expanded in the specimens before me, greyish hyaline with dark veins).

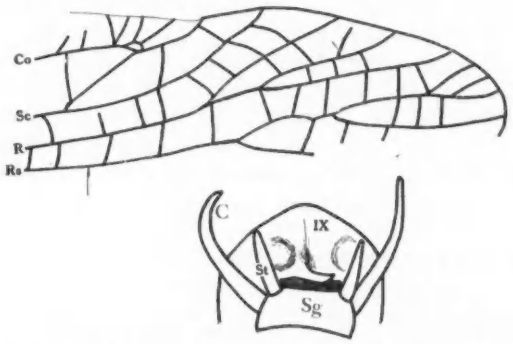


FIG. 2. *Gryllacris melocrania*, ♂ Holotype. Preapical portion of right tegmen (above), and end of abdomen, ventral view (below).

Meso- and metapleuræ concolorous, without black stripes. Knees not at all darkened. Legs concolorous, except all the spines being black, those of hind legs surrounded at base by a black spot. Apical spurs pale, those of hind tibiæ black-tipped. Hind femora on outer ventral margin with 6 spines, the inner margin with a dozen or more spines, the basal ones of the latter very small. Hind tibiæ above on either side six-spined, only the right one of ♀ seven-spined on the outer side.

Abdominal segments concolorous in ♀, partly blackish at base in ♂. Penultimate tergite of ♂ pale, only somewhat darkened along hind margin; ♂ subgenital plate with hind margin truncate, transverse, quite straight. Styles well developed, longer than subgenital plate, (Fig. 2).

Ovipositor straight throughout, by one-fourth longer than the hind femora, rather pointed at the tip; ♀ subgenital plate quite as in ***humberti***, but the basal arcuate keels not black.

All other characters not mentioned in the description above much as in *nigromarginata*.

Differing from both *humberti* and *nigromarginata* at first view by the black occiput and genæ and by the quite concolorous knees of all legs. From *humberti*, moreover, by much smaller size and relatively much longer ovipositor. From *nigromarginata* by the shape of ♂ subgenital plate and much longer styles (♀ of *nigromarginata* not yet known). There are also some differences in tegminal venation, (See Fig. 2).

Type and Allotype in U. S. National Museum. Catalog No. 41225.

Gryllacris fuscinervis var. **evanida** nov. (Plate I, Figs. 1, 3, 5, 6).

The following synonymy of the typical form was established by GRIFFINI in 1913, (Ann. Mus. Nat. Hungar., xi, p. 304).

1877. STAL, Oefv.-Vet. Ak. Forh., 9, p. 47 (*fuscinervis*).
1904. NAVAS, Bolet, Socied. Aragon. Ci. Nat. Zaragoza, iii, 5-6, p. 5, (*scripta*).

1 ♂ (Holotype), 1 ♀ (Allotype). Govt. Lab. Coll., Acc. No. 1004 (without locality). 1 ♂, 1 ♀ (Paratypes), Malabang, Mind., P. I., J. M. T. PARTELLO coll.

In general aspect somewhat resembling *inconspicua*, but with a quite different tegminal venation, being of type III, while *inconspicua* is of type V b.

I name these specimens var. *evanida*, because they have less extended black signs on head and pronotum than the typical *fuscinervis*. Thus they are somewhat intermediate between *fuscinervis* and *brachyptera*, and there can be no doubt that these two Philippine species are quite nearly related, and it is not impossible that they may be nothing else than mere color variations of the same species. At all events, we may state the following series of increasing melanisme: *brachyptera*, *fuscinervis evanida*, *fuscinervis*, *fuscinervis panayensis*, *fuscinervis diamantii*.

The coloration of the specimens now before me is as follows:

♂, Holotype: (Plate I, Fig. 1).—Occiput pale, on either side with a broad, oblique blackish stripe converging forwards and meeting with another on fastigium verticis, which is blackish with a few pale spots and pale margined below and on either side. Eyes dark; antennæ pale throughout. Just below the suture between fastigium verticis and frontis, on either side, a small dark spot. Frons with a vertical dark stripe beginning at the inner lower angle of antennal scrobes and gradually vanishing downwards. Pronotum infuscated along hind margin of the disc and at the hind angle of lateral lobes, with a well-

defined *signifera*-like design on the disc and a dark longitudinal spot on either side of metazona. Fore femora very slightly infumate before the knee; fore and middle tibiæ with a diffuse grey spot below the knee, and with long, pale, movable spines. Hind knees slightly darkened, the extreme tip of hind femora pale, spines of hind legs blackish. Last abdominal tergite somewhat infumate, sternites with two longitudinal rows of large, dark spots.

♀, Allotype: (Plate I, Fig. 3).—Head practically as in the holotype, but broader and less well-defined. The frontal stripes diffuse, occupying nearly the whole breadth of antennal scrobes, reaching downwards to clypeal suture. Dark designs of pronotum arranged practically as in holotype, but slighter and less well-defined. All femora strongly infuscated on either side of distal portion, pale above. All tibiæ dark brown above nearly throughout their whole length. Sternites as in holotype, ovipositor pale.

♂, Paratype: (Plate I, Fig. 5).—Occiput pale brownish. Fastigium verticis pale. Antennal scrobes black margined. First and second segments of antenna blackish at base and at apex. The frontal black stripes confused with another in the middle of forehead, and with the two upper spots (thus surrounding the lower ocellar spot with black), extending downwards to the upper part of clypeus. Pronotum yellowish brown, not conspicuously darkened along hind margin, somewhat infuscate near the hind angle of lateral lobes; disc uniformly colored except a well-defined 7-shaped stripe on either side of the middle. Femora not darkened; tibiæ shining black, except in the apical fourth or fifth.

♀, Paratype: (Plate I, Fig. 6).—Head pale, forehead with both fastigium frontis and verticis blackish. Three ocellar spots yellowish, sublinear, well-defined. Pronotum practically unicolorous, ferruginous. Legs as in ♂ paratype.

	Length of Body	*Pron.*	*Tegmen*	*Fore Fem.*	*Hind Fem.*	*Ovipos.*
♂, Hol.....	19'3 mm.	5'2 mm.	17'7 mm.	7'3 mm.	13'5 mm.	
♀, All.....	18'5 mm.	5'5 mm.	17'2 mm.	8 mm.	14'5 mm.	13'8 mm.
♂, Par.....	19'7 mm.	5 mm.	16'4 mm.	7'2 mm.	12'8 mm.	
♀, Par.....	±18 mm.	5'7 mm.	16 mm.	6'7 mm.	13'2 mm.	13'2 mm.

Sexual characters and venation practically as in *brachyptera* (comp. Phil. Journ. Sci., xxviii, 1, p. 142–144; Plate 3, Fig. 8; Plate 7, Figs. 3, 4; Plate 8, Figs. 1–3).

Tegmina: Two to four precostals, all simple or one of them forked; the last one may arise from costal base. Costal vein simple, reaching fore margin about at the end of middle fifth. Costal area strongly dilated, broadest at about its middle, it extends to the end of basal third of tegmina. Subcostal vein arising from tegminal base, basad straight, then curved forwards, usually with a long apical fork, sometimes simple throughout, in the left tegmen of ♂ paratype four-branched, (Fig. 3 above). Radial vein divided in apical part into three to four oblique, distant branches, (Fig. 3, below), sometimes forked or even simple, on the left tegmen of ♂ paratype emitting only a very

short anterior branch into the last subcostal branch, (Fig. 3 above). Radial sector arising from radial stem usually about in the middle, sometimes more distad, just after the first radial branch (like Phil. J. l. c. Plate 7, Fig. 3); in distal part simply forked or three-branched. Medial free from base, bifurcate about at the end of second fifth, both branches usually remaining simple, sometimes the hind branch forked again a rather short distance before apical margin (Fig. 3 above); on right tegmen of holotype the hind branch not reaching apical margin, but the fore branch, on the other hand, bifurcate again at the end of middle fifth. Cubital vein free, simple, S-shaped. Behind it, follow five simple, free longitudinal veins, only on both tegmina of holotype, the last of them strongly reduced, weak and short.

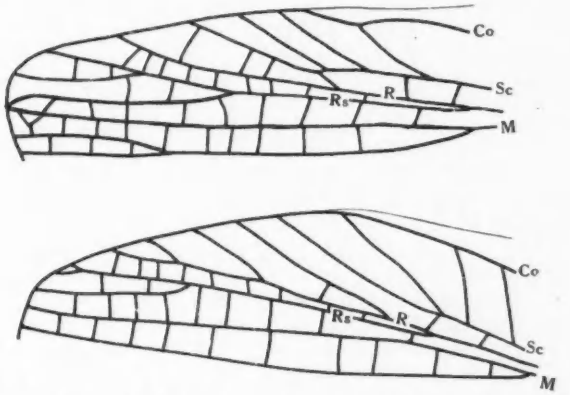


FIG. 3. *Gryllacris fuscinervis evanida*. Apical half (anterior part) of left tegmen. Above: ♂ Paratype; below: ♀ Allotype.

Hind wings: Costal area without cross veins, or only one or two of them basad and distad. Subcostal vein simple. Radial vein emitting in distal part two oblique, distant fore branches into fore margin, like Phil. Journ. l. c. Plate 8, Fig. 3. Rs + M also practically as in that figure, medial vein arising from it in the middle, radial sector then three-branched in about the apical third. Middle part of anal fan with 6 to 11 cross veins in each area.

Type and Paratypes in U. S. National Museum. Catalog No. 41226.

Gryllacris ferruginea Brunner, v. W. (Plate I, Fig. 2).

1 ♂ (det. CAUDELL), Suva, Fiji, vi. 25, '22, DAYTON STONER, on *Guaya*. As it is the only *Gryllacris* species hitherto known from the Fiji Islands, I suppose that to the same species belongs

very probably also a very small larva (length of body 2.5 mm), from Mokaluva, Fiji Islands, June, STONER.

♂.—As to coloration, genitalia and venation quite typical, as described already in some others of my publications. Chief furcation of cubital vein on both tegmina of the specimen now before me arising at the end of basal fourth. Costal field of hind wings with cross veins throughout its whole length; radial vein with a short apical fork.

Gryllacris macilenta Pictet & Saussure.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 29, (*phryganoides*, nec DE HAAN).

1 ♂, Buitenzorg, Java, vi, '09, BRYANT & PALMER Coll. To the same species belongs very probably also 1 juv. ♂, (length of body, 9.5 mm), from the same locality and collectors, iv 10, '09.

The ♂ now before me is an unusually small specimen, viz.: Length of body 17.5, pron. 3.6, tegmen 15, fore fem. 5.8, hind fem. 10.8 mm. This suggests that SERVILLE's *pallidula* may be perhaps identical with this species, not with *auriculata* KRAUSS, as usually supposed. I shall return to this question in some other of my papers.

♂ genitalia and venation as usual in this species, but the latter somewhat reduced. Tegmina with two simple precostals. Subcostal vein emitting just after its middle one oblique anterior branch to costal vein. Both radial vein and radial sector with but a very short, simple, apical fork. Cubital vein simple on left tegmen, forked at beginning of the middle fifth on the right one, but the fore branch not reaching apical margin, ending just before beginning of the apical fifth of tegmina. Not more than four simple postcubital longitudinal veins. Hind wings cycloid. Costal area with but a few cross veins. Medial vein arising from Rs + M at the end of middle fifth. Anal fan in the middle with but 5 cross veins in each area, only in one or two areas with 6.

Gryllacris ruficeps Serville.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 29.

1 ♂ (det. CAUDELL), Mt. Salak, Java, BRYANT & PALMER Coll. 1 ♀ (det. KARNY), Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Both specimens in every respect quite typical (comp. Treubia, V, Pl. II, Fig. 6; Journ. F. M. S. Mus., XIII, p. 28, Fig. 12). Always six free, simple postcubital veins, but on left tegmen of ♀ the second of them (=An_1) forked at the end of basal third. Radial vein of hind wings with a short, apical fork, or emitting two oblique branches to the anterior margin.

Median vein arising from Rs + M at about the middle of wing; Fig. 4 shows a portion of type tegmen of the male. Radial sector in both sexes four-branched. Middle part of anal fan with 7 to 10 cross veins in every area.

Gryllacris lineolata Serville.

1 ♂ (det. KARNY), Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Tegmina: Four simple precostals. Both last precostal and the subcostal vein on both tegmina arising from costal base. Costal vein forked beyond the middle. Subcostal vein with an apical fork, or emitting two oblique branches to the anterior margin. Radial sector forked, or with three branches. Cubital vein arising as usual in this species from radial stem, simple or bifurcate somewhat before the middle of tegmen. Five free, simple postcubitals. Radial sector of hind wings three-branched in apical fourth. Otherwise as described in Zeitschr. f. Naturw., lxxxviii, ½, p. 5; comp. moreover Treubia, V, p. 91, Fig. 30.

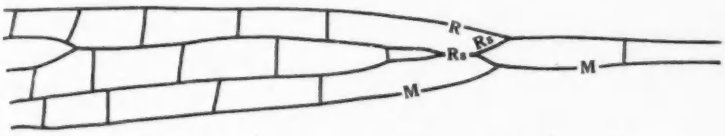


FIG. 4. *Gryllacris ruficeps*, ♂. Left hind wing, middle part of radial and medial vein.

Gryllacris lineolata var. **menzeli** Karny.

1 ♀ (det. KARNY), Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Gr. lineolata menzeli was originally described as a subspecies; but as the specimen now before me comes from the same locality as the typical form, it is to be regarded as a mere color variety.

Venation of tegmina as in the typical form.

Gryllacris si-rambeica griffini var. (Plate I, Fig. 7).

1 ♀ (det. KARNY), Ft. de Kock, Sumatra, WIRT ROBNSON, Collector.

Measurements: ♀, length of body 25.5, pron. 7, tegmen 29.7, fore fem. 10.3, hind fem. 19, ovipos. 22 mm.

As I have shown in another paper, *si-rambeica* originally described as a subspecies of *aethiops* (GRIFFINI, 1908) is to be considered of specific rank, and *fuscifrons* var. *melanica*

GRIFFINI, 1909) does not belong to that species, but to *si-rambeica*.

The specimen now before me is about intermediate in its characters between the typical *si-rambeica* and its var. *melanica*. The coloration of head, pronotum and legs agrees fully with *si-rambeica*, whilst the hind wings are not "hyalino-tessellatæ" as in the typical form, but "fusco-fasciatæ" quite as in var. *melanica* (GRIFFINI, Boll. Mus. Zool. Anat. Torino, xxiv, 610, p. 8, Fig.). Venation of type IV, in every respect agreeing with that of *si-rambeica* and var. *melanica*, as described in another of my papers; the only difference is that the radial vein of hind wing in the specimen now before me is but simply forked in the apical part.

Gryllacris fuscifrons Gerstaecker.

1 ♂ (det. KARNY), Java, SAUSSURE.

I have shown in Treubia (X, 1, p. 73–88; 1928), that *variabilis* BRUNNER v. W. is nothing else than a synonym of *fuscifrons*. The specimen now before me has blackish fastigia, as typical for the true *fuscifrons* (s. str.). Venation of type IV, without any peculiarities or aberrations.

Gryllacris signifera (Stoll).

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 29.

1 ♀, Salak, Java. 2 ♂♂, 2 ♀♀, 1 juv. ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD. 1 ♀, Depok, Java, 8. 1. '09, BRYANT & PALMER Coll. 1 ♂, 1 juv. ♂, Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.

All specimens in every respect quite typical; venation of type IV, though somewhat variable, viz.: Costal vein of tegmina simple or with a few anterior branches, sometimes with an unusually long apical fork (Fig. 5, a). Radial sector emitting distad three to four branches backwards (Fig. 5 a), but in one case forward (Fig. 5, c); on the right tegmen of the Salak-♀ it emits one hind branch and then two fore branches (Fig. 5, b), thus being not regularly pectinate as otherwise always. One of the ♀♀ of FAIRCHILD collection represents on left hind wing a doubled origin of Rs + M (separately for medial vein and for radial sector)—a similar case as figured above for *ruficeps;* but the sector base meets here Rs + M before emitting medial vein, (Fig. 5, d). Compare with Fig. 4.

Gryllacris personata Serville.

1927. Caudell, Proc. U. S. Nat. Mus., lxxi, 3, p. 29, (*falcata*).

As I have shown, *falcata* Brunner v. W. is a synonym of *personata* Serville, whilst Brunner's *personata* is not the Servillean species, but a synonym of *eta* Karny.

1 ♀ (*falcata* det. Caudell), Buitenzorg, Java, iii, '09, Bryant & Palmer Coll.

A quite typical specimen. Coloration of face, see Treubia, VII, 1, Plate 1, Fig. 7, d. Venation according type IV.

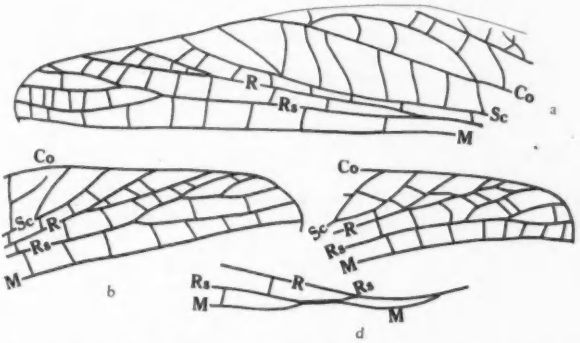


Fig. 5. Variations of tegminal and wing venation in *Gryllacris signifera*. (a) ♀, Salak, preapical part of left tegmen; (b) the same, right tegmen; (c) first ♂, Fairchild collection, preapical part of tight tegmen; (d) second ♀, Fairchild collection, doubled origin of Rs+M from radial vein on left hind wing.

Gryllacris caudelli n. sp. (Plate I, Fig. 8).

1 ♀ (Holotype), Puerto Princesa, Palawan, P. I., Sept., 1925, R. C. McGregor, Collector.

Measurements: ♀, Length of body 23.3, pron. 5.2, tegmen 23.5, fore fem. 8.3, hind fem. 13.7, ovipos. 18 mm.

A very peculiar species. Rather small and slender. General color cinnamon-buff with black.

Head a little wider than pronotum, obovate and somewhat elongate in frontal view; general color shining black, except occiput, vertex, fastigia, hind margin of genæ, ventral and side margins of clypeus and the whole of palpi. Occiput strongly arched, clay-color, with a large, triangular, not well-defined dark brown spot in the middle. Supraocular sulci sharp. Vertex convex; fastigium verticis about as wide as first antennal segment, longitudinally shallowy excavate, with blunt, indistinct lateral carinæ. Antennal scrobes shining black, only the weak pellicle at the insertion of first antennal joint paler,

greyish, though with a blackish spot inside. The five or six basal joints of antennæ quite shining black, the following ones gradually becoming paler, rest of antennæ yellowish brown. Frons shining black, about twice as wide as high, with a few strongly impressed dots, about as in *podocausta*, much fewer than in *modiglianii*, clypeo-frontal suture strongly impressed on either side and somewhat dilated mesad. Subocular sulci distinct, triangularly dilated downwards. Genæ smooth, black, narrowly clay-color along upper part of hind margin. Clypeus trapezoidal, in lower part with a sharp, deep length sulcus; color, shining black, narrowly bordered with cinnamon-buff below and outside. Mandibles and labrum shining black throughout, the latter about circular. Palpi long, cinnamon-buff; apical joint of labial palpi dilated distad, with a strongly oblique, excavate apical area.

Pronotum not very broad, including lateral lobes about as wide as long; sculpture practically as in *maculipes irregularis* (GRIFFINI, Ann. Mus. Nat. Hungar., IX, p. 175, 1911); hind angle of lateral lobes obliquely truncate. General color cinnamon-buff, with sharp, well-defined black markings, viz.: the median sulcus black in the middle third of the disc; on either side of its posterior end a short oblique black line; before its anterior end on either side a considerable, transverse black spot, and before this a fine oblique blackish line descending on lateral lobes towards but not quite to the fore margin. A very large black irregularly crescent-shaped spot about the middle of lateral lobes, the convex side dorsal. Behind this large spot is a small black dot just under the middle of hind oblique sulcus. Posterohumeral cone short and thick, but acute at apex. Prosternum unarmed. Meso- and metasternum impressed in apical part of median line; the former with obtusangulately excised hind margin and broadly rounded lobes; the latter rectangularly excised with bluntly rectangular lobes.

Tegmina much exceeding tips of posterior femora, pale yellowish, subhyaline, with longitudinal veins of the same color or a little darker; cross veins in about the apical half greyish and suffused on both sides by a greyish cloud. Four simple precostals, the last convex in basal part and then rather parallel to costal vein. This latter slightly S-curved, simple, ending about between the ends of middle fifth and third of tegminal length. Costal area of the same constitution as the others, dilated distad, widest at the end of costal vein. Subcostal vein arising from costal base, straight, then curved forward before the end, emitting one or two short, oblique, anterior branches to the fore margin. Radial vein emitting in apical part two oblique anterior branches rather distant from each other to the anterior margin. Radial sector arising from radial vein about the middle of tegmen, with two posterior branches, the longer being hardly half as long as sectoral stem. Median vein arising from radial stem at about the beginning of the middle fifth, simple and free throughout. Cubital vein free from base, bifurcate just before the middle of tegmen. Now follows five simple longitudinal veins, the last two of them with a short common stem.

Hind wings cycloid, a very little paler than tegmina, with strong dark cross bands, even in the preanal part, the pale intervals between

them distinctly wider than the dark bands. Costal area with cross veins throughout the whole length. Subcostal vein unbranched, fused with radial basally. Radial vein forked before the end. Rs + M arising from radial stem at the end of basal third, emitting the simple medial vein at the middle of wing. Radial sector emitting in apical third of wing two posterior branches which unite with each other in the distal part on left wing (Fig. 6), whilst remaining free to the apical margin on the right one. Cubital vein unbranched, arising from radial stem at about the end of basal sixth or seventh. Middle part of anal fan with 5 to 8 (usually 7) cross veins in each area.

Pleuræ, coxæ, trochanters and legs pale, cinnamon-buff, all femora in distal part well-defined shining black; fore tibiæ black throughout, except the clay-color spines; middle and hind tibiæ black in basal part and with a blackish spot before the end. All tarsi reddish-brown.

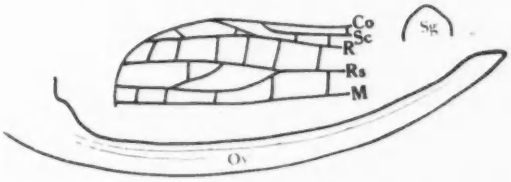


FIG. 6. *Gryllacris caudelli*, ♀ Holotype. Apical part of left hind wing; ♀ subgenital plate; ovipostor.

Fore coxæ with a short, thick, sharply pointed spine. The movable spines of fore and middle tibiæ of usual number, distinctly longer than the width of tibia. Hind femora in distal half with 6 to 7 dark-tipped spines on the outer ventral margin and 3 to 5 smaller ones on the inner margin. Hind tibia with 6 dark-tipped spines on each dorsal margin.

Abdomen pale, cinnamon-buff to clay, without dark markings; ♀ subgenital plate parabolic, not excised at the tip, considerably wider at base than long. Ovipositor one-third longer than posterior femora, equally and slightly upcurved, somewhat truncate apically and rather bluntly pointed, (Fig. 6).

Type in U. S. Nat. Museum. Catalog No. 41227.

I have the pleasure to name this brightly colored species in honor of Mr. A. N. Caudell, the well-known American Orthopterist, to whose kindness I owe the occasion of studying this interesting material.

This species was mistaken by CAUDELL for *vittipes* WALKER, because it is quite impossible to determine anything after the quite insufficient WALKER'S descriptions. As I have studied all WALKER'S type specimens of Gryllacrids (in the British Museum, London, and in the University Museum, Hope

Department, Oxford), I can state that *Gryllacris caudelli* is not near-related with that nor with any other Philippine species. Its nearest allies are amongst the Bornean species, viz.: *moultoni* GRIFFINI, *podocausta kuchingiana* GRIFFINI and *maculipes* WALKER. By the black head, it differs at once from *moultoni* and *maculipes* and agrees in this character and by the coloration of legs with *podocausta kuchingiana* only, but differing from it by coloration of pronotum, by the longer tegmina and wings, by the pale longitudinal veins of the former and the strong dark crossbands of the latter, moreover by much longer ovipositor. From *moultoni*, it differs by color of head, pronotum and legs and by the relatively longer ovipositor. From *maculipes* (and its var. *irregularis* GRIFFINI), *caudelli* differs by the black head, by different coloration of pronotum and by the color of tegminal veins which are paler than the areolæ between them in *maculipes*, whilst being of the same color and partly even darker in *caudelli*. The ♀ of *maculipes* is not yet known, as WALKER'S description is quite insufficient, and I could find in the material of British Museum only the ♂, not the ♀. But a ♀ from Borneo in the Leyden Museum collection, which agrees in many respects with *maculipes* though differing by some color characters, has a considerably shorter ovipositor than *caudelli* and the subgenital plate distinctly excised at apex.

Subfamily RHAPHIDOPHORINÆ.

Rhaphidophora loricata (Burmeister), (nec. Kirby).

1838. BURMEISTER, Handb. Ent., II, p. 722, (*Phalangopsis*).
1839. SERVILLE, Hist. Nat. Ins. Orth., p. 391, (*picea*).
1906. KIRBY, Syn. Cat. Orth., II, p. 124, (*brunneri*).
1927. KARNY, Zeitschr. Nat., lxxxviii, p. 11.
1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 28, (*deusta*, nec BRUNNER v. W.).

1 ♂ (with a label "*deusta*," without indication of determinator), Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll. 1 ♀, Mt. Salak, Java, BRYANT & PALMER Coll. 2 ♂♂, 2 ♀♀, 2 juv. ♂♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Quite typical specimens, also as to the shape of ovipositor, ♀ subgenital plate and ♂ styles; distinctly different from both *deusta* and *fulva*. (See my notes on these two species in the revision of Gryllacrids of Vienna Museum, now in press).

Family TETTIGONIIDAE.

Subfamily SCAPHURINÆ.

Comp. KARNY, Treubia, IX, p. 12–151; 1926.

Elimaea (**Rhaebelimaea**) **bakeri** Hebard.

1922. HEBARD, Proc. Ac. Nat. Sci. Philad., lxxiv, p. 125.

1 ♂, Malabang, Mindanao, MAJ. J. M. T. PORTILLO, Rec'd July 31, '08.

Elimaea (**Rhaebelimaea**) **filicauda** Hebard.

1922. HEBARD, Proc. Ac. Nat. Sci. Philad., lxxiv, p. 127.

1 ♂, 1 ♀ (Allotype), Manila, P. I., August 21, 1924, R. C. MCGREGOR, Collector.

The ♀ of this curious species, is as yet unknown. It agrees quite all right in every respect with the ♂. Its measurements are:

♀, Length of body 25, pron. 4'3, tegmen 39, width of tegmen 5'5, length of fore fem. 9, hind fem. 35'3, ovipos. 5'7 mm.

Ovipositor short, strongly compressed, upcurved, blunt at apex, upper margin and end of lower margin denticulated; ♀ subgenital plate triangular, rounded at apex, a little wider at base than long, without any processes.

Elimaea (**Rhaebelimaea**) **kraussi** Karny.

1903. KRAUSS, SEMON, Zool. Forsch. Austral., V, p. 748, 762, (*signata*, nec BRUNNER, v. W.).
1923. KARNY, Journ. Mal. Br., R. As. Soc., I, p. 135, (*parumpunctata*, nec SERVILLE).
1926. KARNY, Treubia, IX, 1–3, p. 31, fig. 92.
1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33, (*curvicercata*, nec BRUNNER v. W.).

1 ♂, Mt. Salak, Java, BRYANT & PALMER Coll.

I have not yet seen BRUNNER'S *curvicercata;* but it is recorded from Eastern Java only and seems from BRUNNER'S description to differ from *kraussi* by the sexual characters. Thus, I cannot believe that they are identical.

Elimaea (**Elimaea**) **poaefolia** (De Haan).

1926. KARNY, Treubia, IX, 1–3, p. 37, fig. 97.
1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33, ("species").

1 ♀, Pelaboean Ratoe, Java, BRYANT & PALMER Coll.

CAUDELL (l. c.) stated quite correctly that it "is apparently allied to the *E. rosea*," but he seems to have overlooked that the Western Javanese species of the *rosea* group is *poaefolia* DE HAAN, 1842.

Aphroptera biroi Bolivar.

1 ♂, New Guinea, B. P. CLARK, donor.

Agreeing with BOLIVAR'S description, except that the antennæ are uniformly ferrugineous, without black basal joints nor with distinct pale rings. The black stripe on fore tibia very distinct.

Paracaedicia verrucosa Brunner, v. W.

1 ♂, New Guinea, B. P. CLARK, donor.

I have completed BRUNNER'S description in 1926 in Treubia (IX, p. 65).

Ancylecha fenestrata (Fabricius).

1 juv. ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

This stage described and figured in Treubia, 1921 (I, 4, p. 296).

Casigneta spec.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33, ("*Symmachis subroseata* Walker?").

1 ♀, Buitenzorg, iii, '09, Java, BRYANT & PALMER Coll.

Measurements: Length of body about 14, pron. 3'5, tegmen 27'7, fore fem. 4'8, hind fem. 18'8, ovipos. 5'6 mm.

I cannot believe that the genus *Symmachis*, without exception Australian, should occur in Western Java. The specimen before me agrees very well with the *cochleata* group of *Casigneta* by shape of fastigia, venation of tegmina, shape of ovipositor and of ♀ subgenital plate. But the tympana of fore tibiæ are distinctly open on both sides, whilst being conchate inside in *Casigneta*. The specimen before me has only one fore leg and the tarsal joints of it are very short and weak, though normal in number; thus, it may be probably an anomalous fore leg (regenerate?), and in such we find very often open tympana instead of normally conchate ones. I find it best, therefore, to place this specimen to *Casigneta*, which is represented in Java too, but I do not know hitherto any Javanese species of the *cochleata* group. This specimen is, therefore, very probably to be considered as a new species, though it is impossible to describe it from a ♀ only.

Elbenia nigrosignata Stal.

2 ♂♂, Puerto Princesa, Palawan, P. I., October, 1925, R. C. McGregor Coll.

They may perhaps represent a distinctive local race or subspecies of this species described from Malay Peninsula, though the material before me is too poor to decide this with certainty. The only difference I can state is that the narrow, sharply pointed lobes of anal segment are rather parallel (Fig. 7), much less divergent than in typical *nigrosignata*.

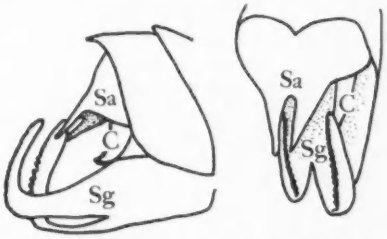


Fig. 7. *Elbenia nigrosignata* from Puerto Princesa, Palawan. End of ♂ abdomen in lateral and hind view.

Psyra melanonota Stal.

1927. Caudell, Proc. U. S. Nat. Mus., lxxi, 3, p. 34, (*borneensis*, nec Brunner v. W.).

1 ♂, Buitenzorg, Java, iii, '09, Bryant & Palmer Coll.

Though Caudell has determined it for *borneensis*, he compared it with *melanonota* too (l. c.), stating that in the cerci "the subapical inner tooth is smaller than in a male of that species determined by Hebard from the Moluccas." But this is a variable character in this species as stated by Hebard in 1922, (Proc. Ac. Nat. Sci. Philad., lxxiv, p. 154). Though the western specimens of *melanonota* usually have the whole disc of pronotum reddish brown, the specimen before me shows this color in the posterior portion only, margined behind by black. Otherwise no difference from typical specimens; also the bright bicolorous costal stripe in tegminal base is present.

Holochlora paradoxa Karny.

1926. Karny, Treubia, Ix, 1–3, p. 122.
1927. Caudell, Proc. U. S. Nat. Mus., lxxi, 3, p. 34, (*venosa*, an Stal?).

1 ♀, Buitenzorg, Java, iii, '09, Bryant & Palmer Coll.

As I have discussed l. c., it is not quite impossible that my *paradoxa* may prove to be a synonym of *venosa*, but Stal's description is too laconic to make it out with certainty.

Holochlora signata bogoriensis Karny.

1926. Karny, Treubia, IX, 1-3, p. 124.
1927. Caudell, Proc. U. S. Nat. Mus., lxxi, 3, p. 34, (*Psyra unicolor*, nec Brunner, v. W.).

1 ♂, Mt. Salak, Java, Bryant & Palmer Coll.

Caudell has mistaken it for a *Psyra*, as he had no ♀ specimen before him, and the generic differences between *Holochlora* and *Psyra* are based, unfortunately, on ♀ characters only. As I know also the ♀ ♀ of *bogoriensis*, there can be no doubt that its position in *Holochlora* is correct.

Subfamily Pterophyllinæ.

Pseudophyllus titan White.

1895. Brunner, v. W., Mon. Pseudophyll., p. 40, (*Cleandrus rex*).

1 ♀ (det. Caudell), Lem Sing Prov. of Chantabun, S. E. Siam, June 12, 1926, H. M. Smith Coll.

Onomarchus spec.

1927. Caudell, Proc. U. S. Nat. Mus., lxxi, 3, p. 32, (*Pseudophyllus titan*, nec White.

1 juv. ♂, 1 juv. ♀, Buitenzorg, Java, iii, '09, Bryant & Palmer Coll.

The spines of hind legs are much better developed in young specimens than in adults, and resemble very much *Pseudophyllus titan* indeed. This is the reason that Caudell mistook them for that species. But the shape of pronotum, on the other hand, is quite typical for *Onomarchus*. I kept repeatedly such juveniles living, and they develop to quite typical *Onomarchus* adults. They belong, thus, certainly to one of the two following species, but I am not able to distinguish them in this stage.

Onomarchus leuconotus (Serville).

1839. Serville, Hist. Nat. Ins. Orth., p. 469, (*Pseudophyllus*).
1892. Pictet & Saussure, Icon. Saut. Vertes, p. 15, (*latipennis*).
1924. Karny, Treubia, V, 1-3, p. 179.
1927. Caudell, Proc. U. S. Nat. Mus., lxxi, 3, p. 32, (*leuconotus* partim).

1 ♂ ("*leuconotus* var. *latipennis*" det. Caudell), Depok, Java, 1. viii, '09, Bryant & Palmer Coll. 1 ♀, Buitenzorg, Java, iii, '09, Bryant & Palmer Coll.

Onomarchus mandarinus Pictet & Saussure.

1 ♂, Java, Nr. 296. 1 ♀ ("leuconotus" det Caudell), Mt. Salak, Java, 15. v. '09, Bryant & Palmer Coll.

BRUNNER, v. W. in his monograph (p. 43) has confounded this species with the preceding one, and CAUDELL followed him in this (l. c.). Other authors have named the species "*cretaceus*," but the Servillean description makes it clear that this must be regarded as identical with *submuticus* BRUNNER, v. W., as I have shown in 1924 (Treubia, V, 1–3, p. 178, 180). Thus, the only available name for it is *mandarinus*.

Despoina submutica n. sp. (Fig. 8).

1 ♂ (Holotype), Mt. Kinabalu, N. Borneo, 5–6,000 ft., A. D. DODGE & G. A. GOSS, collectors.

♂, Length of body 34, pron. 6, tegmen 62'5, fore fem. 7'8, hind fem. 17 mm.

A very distinctive species, running by its much produced, lobate conchs of fore tibial auditory organs to *Despoina* BRUNNER, v. W.

General color yellowish green, head and pronotum more yellow. Antennæ unicolorous, yellowish, without any dark markings. Pro-

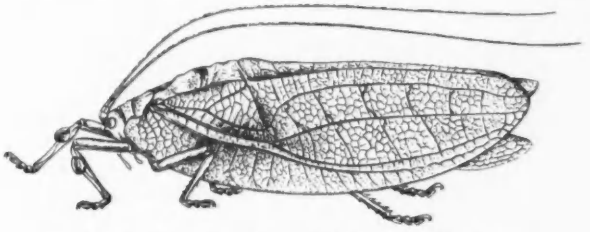


FIG. 8. *Despoina submutica*, ♂ Holotype. Natural size. (SOEHANAM del.)

notum with fore and hind margins equally rounded, smooth. Disc with one indistinct and close behind it one very sharp, deep cross sulcus, this latter situated before the middle; no longitudinal sulcus, except a very short longitudinal groove crossing the second transverse sulcus; surface of pronotum sprinkled irregularly with blunt, very short teeth, not situated in rows, reaching neither fore nor hind margin. Color uniformly pale, except the second cross sulcus, which is brownish red, and a narrow curved line just along hind margin of the same color which is triangularly dilated in the middle. The hind margin itself pale.

Tegmina very long and wide; pale green; the strong cross vein of stridulating field (left tegmen) broadly bordered with ferrugineous brown, and some of the irregular cross venules of anal area of the same color. The long, regular cross veins of the distal two-thirds between radial vein and radial sector, and between radial sector and medial vein, rose colored with an intensively yellow spot at junction with

longitudinal veins. Subcostal and radial veins distant from each other throughout their whole length, about as in *spinosa*. Radial sector arising from radial vein at about the end of basal third. Medial vein equally distant from radial in basal third as the radial is from the subcostal vein, then strongly curved backwards; radial sector equally distant from radial as from medial vein. Stridulating field much shorter than in *superba*.

Legs pale brownish yellow. Fore and middle femora beneath on both margins with some small spines, those of the former bearing very minute, serriform denticles, those on the latter somewhat larger. Posterior femora with about a dozen stronger spines increasing apically on either lower margin. Conchs of fore tibial tympana strongly lobate, arched, rounded. ♂ genitalia as usual in this and the allied genera.

Type in U. S. National Museum. Catalog No. 41228.

Sathrophyllia femorata (Fabricius).

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33.

1 ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Subfamily MECONEMINÆ.

As I have shown in 1924 (Treubia, V, 1-3, p. 105–108), the genus *Xiphidiopsis* does not belong to the Listroscelinæ, where it was previously placed by the authors, but certainly to the Meconeminæ.

Xiphidiopsis picta Karny.

1924. KARNY, Treubia, V, 1-3, p. 110, 113, fig. 37.
1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 30, (*fallax*, *nec* REDTENBACHER).

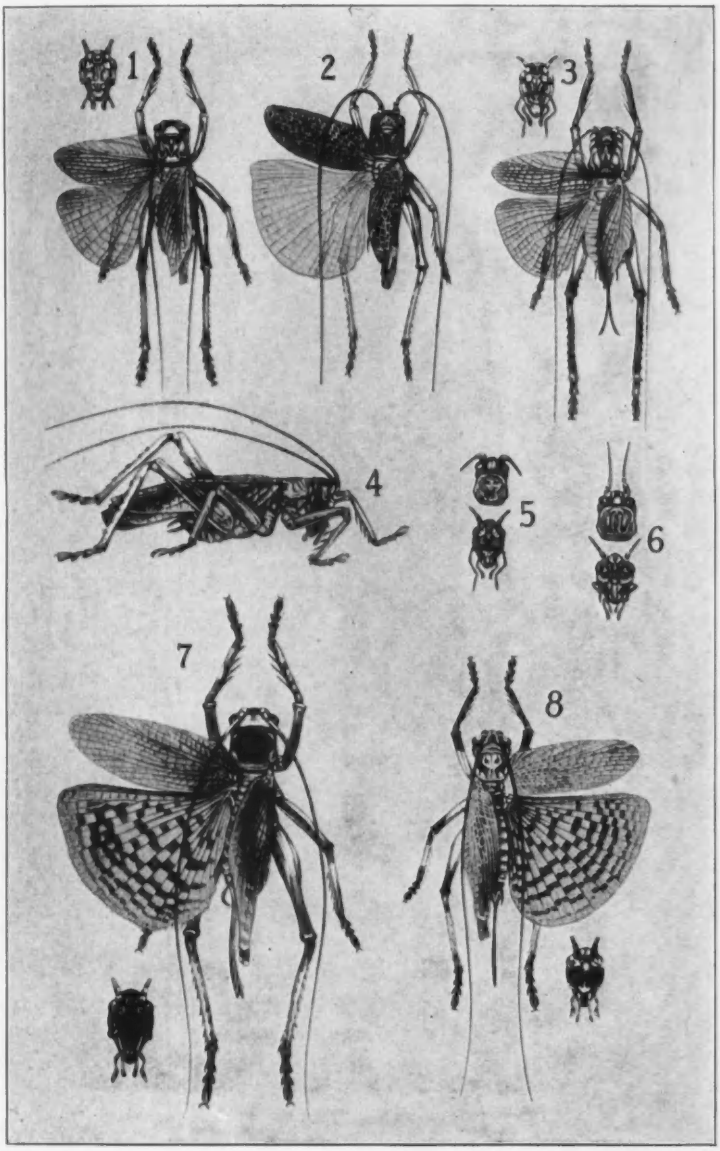
1 ♂, Mt. Salak, Java, 15. v. '09, BRYANT & PALMER coll.

Compared with type specimens in Buitenzorg Museum and agreeing with them in every respect. Differing from *fallax* by coloration and by the shape of ♂ genitalia, though REDTENBACHER's description is not sufficient. *X. fallax* is an Eastern Javanese species and does not occur in Western Java.

EXPLANATION OF PLATE.

(Slightly less than natural size, SOEHANAM del.)

Fig. 1. *Gryllacris fuscinervis evanida*, ♂ holotype.
Fig. 2. *Gryllacris ferruginea*, ♂.
Fig. 3. *Gryllacris fuscinervis evanida*, ♀ allotype.
Fig. 4. *Gryllacris melanocrania*, ♂ holotype.
Fig. 5. *Gryllacris fuscinervis evanida*, ♂ paratype.
Fig. 6. *Gryllacris fuscinervis evanida*, ♀ paratype.
Fig. 7. *Gryllacris si-rambeica* var., ♀.
Fig. 8. *Gryllacris caudelli*, ♀ holotype.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BASES FOR THE GENERIC CLASSIFICATION OF THE COCCOID FAMILY COCCIDÆ.

JOHN BENJAMIN STEINWEDEN,
City Horticultural Comm., San Francisco.

INTRODUCTION.

The group of scale insects here to be considered has commonly been characterized as the Lecaniine scales, owing to the fact that the genus *Lecanium* was for long regarded as its type. With the shifting of the group type to the genus *Coccus* it has been generally accepted as the subfamily *Coccinæ* of the family *Coccidæ*. The group appears, however, to be of family rank, a position that has been suggested by Professor Ferris, and it will therefore be treated in this paper as the family *Coccidæ* of the superfamily *Coccoidea*.[1]

The group is generally considered to be very difficult and previous systematic work has contributed comparatively little to the understanding of the relationships and the classification of the existing forms. But little attention has been paid to the more obscure morphological characters and most of the keys are based upon external appearances, body secretions and comparative measurements of legs and antennæ, all of which have proved to be inadequate and in many cases quite useless. In this study I have attempted to establish a classification based primarily upon morphological characters.

Sixty or more genera have been named in this group and of these I have examined representatives of thirty-two, these including especially the older genera. Habit, body secretions, the males and comparative measurements are but briefly considered. The work has been based almost entirely upon the morphological characters of the adult females and of the first stage larvæ, where the latter were obtainable. While eventually the males must be studied also, that has not been possible as yet, owing to the scarcity of material.

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[1]Although the spelling *Coccidoidea* has previously been used for the superfamily name of the scale insects, it would appear that the proper form is *Coccoidea*.

Acknowledgments are due to Professor G. F. Ferris, by whom this paper was suggested and who has given advice and other aid in its preparation. They are also due to Mr. E. E. Green for the gift of valuable material and for helpful suggestions that he has offered. The material upon which the paper is based has for the most part come from the collection of *Coccidæ* of Stanford University.

Methods.

Much of the difficulty experienced in dealing with this group has been due to the unsatisfactory methods usually employed in the preparation of microscopic mounts. First class preparations are essential for systematic work and I have used specimens that were cleared, stained and mounted according to the methods of modern Coccidologists.

In preparing material it is important to secure specimens that are in the early adult stage when the derm is soft and membranous. If the derm has become sclerotic and pigmented it is impossible to determine the character of the ducts and pores, which are very important in a systematic study of the group.

Position of the Group.

As I have previously stated, I am here treating the group as a family of the *Coccoidea*. It may be defined by the following characters. *Coccoidea* in which the adult female possesses an anal cleft the base of which is covered by an operculum formed of two plates; anal opening invaginated and surrounded by a distinct, setigerous anal ring; usually with four stigmatic depressions with prominent stigmatic setæ; usually with well developed legs and antennæ. Without abdominal spiracles, dorsal ostioles, cerarii, or brachii.

There are two theories as to the possible relationships of this family with the other families of the *Coccoidea*. One, held by Mr. E. E. Green, maintains that they are most closely related to the forms that group about *Eriococcus*. The other suggests a relationship to the forms centering about *Asterolecanium*.

The theory of relationship to the Eriococcids is based principally upon the similarity of the anal plates of the *Coccidæ*

to the anal lobes in the former group. *Mallococcus*, a Coccid, has small, lobe-like anal plates much like the anal lobes of some Eriococcids. *Pseudo-pulvinaria sikkimensis* Atk., too, has small anal plates around the anal ring which look like the anal lobes of Eriococcids. In fact this species has been placed with the Eriococcids. It is not difficult to imagine the anal lobes becoming retracted into an anal emargination and finally forming plates at the anterior end of a cleft. The first stage larval forms of *Eriococcus* have sclerotic anal lobes that are very similar to the anal plates of first stage Coccids. The fact that the anal plates of this stage in the Coccids bear a long apical seta, as do the anal lobes of the *Eriococcids* and many other forms, would seem to indicate this homology.

On the other hand, in support of the theory of relationship to the Asterolecaniids, there is the fact that certain of the *Coccidæ* possess 8-shaped pores that resemble those of the Asterolecaniids, although they are apparently not identical in structure. The adult females of *Lecaniodiaspis* have slight stigmatic depressions, which bear modified stigmatic setæ. They have also a shallow anal cleft, the base of which is sclerotic. It has been suggested that anal plates could have been evolved from these sclerotic areas. The first stage larvæ of *Lecaniodiaspis*, however, have no structures resembling the anal plates of the first stage *Coccidæ*.

It appears probable, therefore, that the closest relationship of the group is actually with the Eriococcids. Professor Ferris who has previously held a belief in a connection with the Asterolecaniids now accepts the opposing view.

The genus *Aclerda* has been placed with the *Coccidæ* by some authors. Green has questioned this position and has placed the genus alone in an isolated position. Teague, who has reviewed the genus *Aclerda*, concurs in this opinion and excludes the genus from the *Coccidæ*. With this opinion I concur.

The Existing Generic Classification.

The existing generic classification of the *Coccidæ* is based almost entirely upon external characters such as the presence or absence of an ovisac; the presence or absence of a waxy body covering and its character; the shape of the body, whether oval or elongate, convex or flat; the habits of the insects,

whether arboreal or subterranean the character of the derm, and color. Such characters are easy to recognize, but are too indefinite to make accurate discrimination possible or to serve

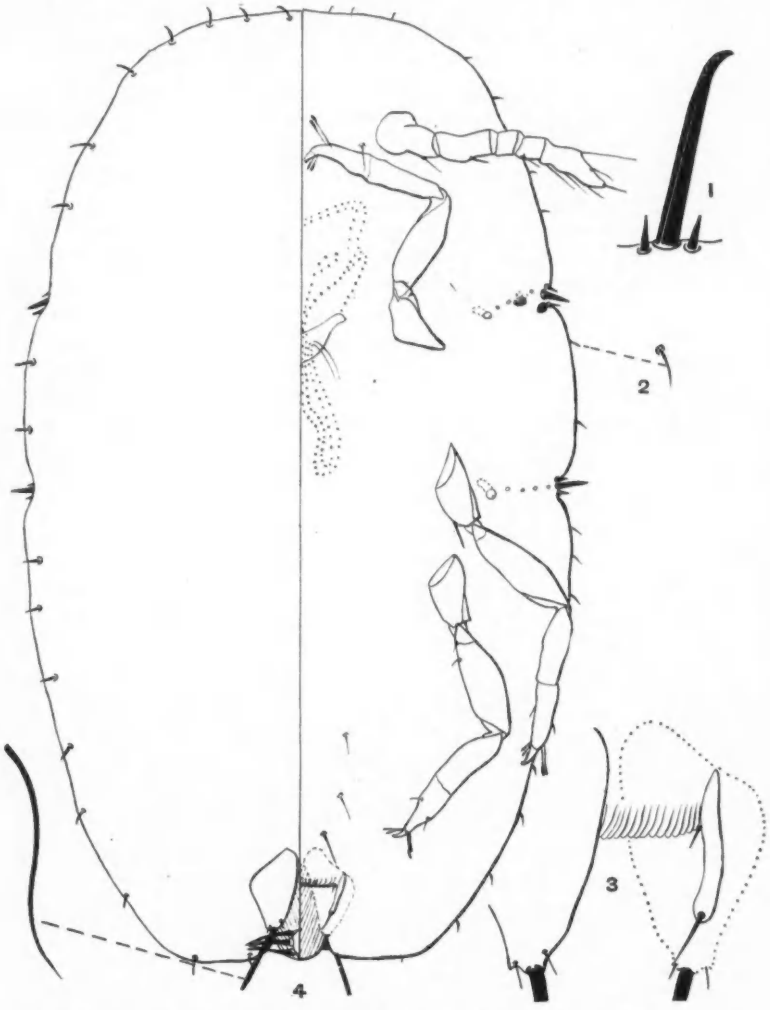

Fig. I. *Coccus hesperidum* Linnaeus, first stage. 1, stigmatic setæ; 2, marginal seta; 3, anal plates; 4, general outline.

as the fundamental bases of a classification. Commonly but little attempt has been made to utilize morphological characteristics of a more obscure nature, either because such characters are not easily observed or because they have not been thought necessary in taxonomic work.

As a result we have generic keys for this group which are of little practical value for classification, and a group of genera indefinitely defined and probably including many misplaced species. In the following pages several changes are made in the generic classification, all of these being based upon morphological studies.

Morphology of the Family.

LEGS.

All of the members of the family retain the legs in the adult female, those of the majority of the species being well developed with all parts present. A few have the legs somewhat reduced, while in two genera examined, *Cryptostigma* and *Cardiococcus*, they remain merely as unsegmented vestiges. The legs most typical of the group are large, with all the parts present, with two slender digitules arising from the dorsal aspect of the tarsus and two stouter digitules from the claw. In *Coccus*, *Saissetia*, *Pulvinaria*, *Lecanium*, *Ceroplastes* (with the exception of *C. rubens*), *Lichtensia*, *Vinsonia*, *Inglisia*, *Mallococcus* and several other genera the legs are well developed.

In *Physokermes*, *Eriopeltis*, *Lecanopsis* and *Ceroplastes rubens* the legs are somewhat reduced, but all the parts are present. In *Toumeyella*, and *Neolecanium*, the reduction in size has been carried still farther but still all the parts are present. In *Cryptostigma* and *Cardiococcus fossilis* only the claw can be recognized.

Although many descriptions pay much attention to the legs, giving the measurements of the parts in microns and describing minutely the vestiture of setæ, I have found such characters to be of but little taxonomic value. Where the legs are reduced this character may be of supplementary value, but it cannot serve as a primary basis for classification. *Ceroplastes rubens*, although in all other respects typical of its genus, has the legs greatly reduced. In the case of *Cryptostigma* and *Cardiococcus* the character is undoubtedly important.

One character of the legs that is important is that of the presence or absence of a free tibio-tarsal articulation. Green[2] has called attention to this character and states that typical examples of the genus *Pulvinaria* have a free tibio-tarsal articulation with a heavily sclerotic articular process interlocking with the distal extremity of the tibia. I have found this condition to hold in all the species of *Pulvinaria* that I have seen and in *Saissetia hemisphaerica* (Fig. III, 4). I have also found the typical species of *Lecanium* to lack this free articulation, a character for the separation of these closely related genera thus being available. *Coccus hesperidum* also lacks this free articulation (Fig. II, 4). In the generic diagnoses following attention is called to this.

All of the *Coccidæ* that I have examined have the tarsi one-segmented. *Exaeretopus* was originally described by Newstead as having the anterior tarsi dimerous, but Green has shown that this interpretation is erroneous, there being no true articulation. The apparent joint is merely a wrinkle formed because of the curvature of the tarsus. I have found an apparently rudimentary suture in *Eucalymnatus tessellatus, Hemilecanium imbricans* and *Takahashia japonica*.

ANTENNÆ.

The antennæ, like the legs, have been used often in generic and specific descriptions, their total length and the number and lengths of the individual segments having been relied upon. In this paper I am concerned principally with generic characters and have found the antennæ to be of but little value. In most of the Coccid genera the antennæ are long, fairly slender, six- to eight-segmented, the third and fourth segments usually being the longest. The basal segment is stouter than the others, which usually taper to a slender, pointed apex. *Coccus, Saissetia, Pulvinaria, Lecanium, Ceroplastes* (with the exception of *rubens*), *Lichtensia, Vinsonia, Mallococcus* and several other genera have antennæ of this type. In *Takahashia, Physokermes, Inglisia, Cryptes, Eriopeltis* and *Ceroplastes rubens* the antennæ are of this same general type but shorter. In *Toumeyella, Neolecanium, Pseudophillipia, Lecanopsis, Cryptostigma*

[2]Green, E. E. Observations on British Coccidæ II. Ent. Mon. Mag. 64: 22; f. 2, (1928).

and *Cardiococcus* the antennæ are quite small, being reduced to four or five segments.

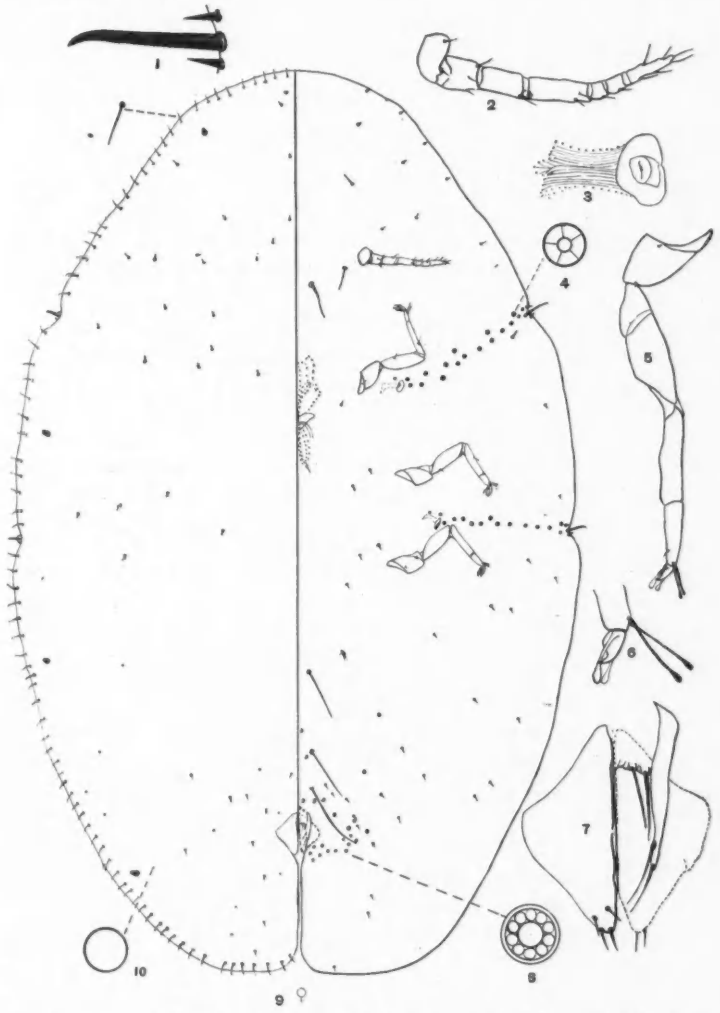

Fig. II. *Coccus hesperidum* Linnaeus, adult female. 1, stigmatic setæ; 2, antenna; 3, spiracle; 4, quinquelocular pore; 5, leg; 6, claw; 7, anal plates; 8, multilocular pore; 9, general outline; 10, simple pore.

There is a certain correlation between the character of the antennæ and the legs, those species with large, well developed legs usually having well developed antennæ and a reduction in the antennæ usually accompanying a reduction in the legs.

ANAL PLATES.

The posterior cleft and the anal plates appear as the most characteristic features of this group and consequently have received considerable attention from students. The two heavily sclerotic plates, forming the anal operculum are usually triangular in shape and lie at the base of the anal cleft above the opening of the anal tube. They are supported usually by two sclerotic, internal processes. These plates are present in the larval stages of all species and in the adults excepting only the genus *Physokermes* in which they are lost at the second molt, giving way to a membranous median lobe.

Setæ may be borne on various parts of the plates, as *apical setæ* at or near the apices, *discal setæ* on the dorsal surface, *subapical setæ* on the ventral surface, *fringe setæ* along the margin of the fold made by the invagination of the anal tube and *hypopygial setæ* on the ventral surface of the body just anterior to this fold.

The anal opening is borne at the inner extremity of a short, membranous, eversible tube and is surrounded by a well defined ring which bears six or eight stout setæ. The comparative length of the anal cleft, the number and arrangement of the setæ, and the shape and comparative proportions of the plates have all been utilized in systematic work.

In searching for structural characters of use in taxonomy I have studied the anal plates of many species in the more important genera and have found that in generic diagnosis the anal plates of themselves are generally of little value. They are useful for specific differentiation and in a few cases for generic classification. Examples of genera that may be defined by means of the anal plates follow.

Cissococcus: Plates elongate, lateral margins rounded and not angulate, disc closely beset with short, stout setæ.

Protopulvinaria: Anal cleft running far into the body, cephalolateral margin of the plates much longer than the caudolateral margin, the plates themselves much longer than wide.

In some genera the plates present supplementary characters for generic diagnosis.

Saissetia: A single large discal seta present on each plate.

Ceroplastes: Plates borne on a tubercle.

Toumeyella: Hypopygial setæ present, small discal setæ present on the posterior half of the plates, operculum quadrate.

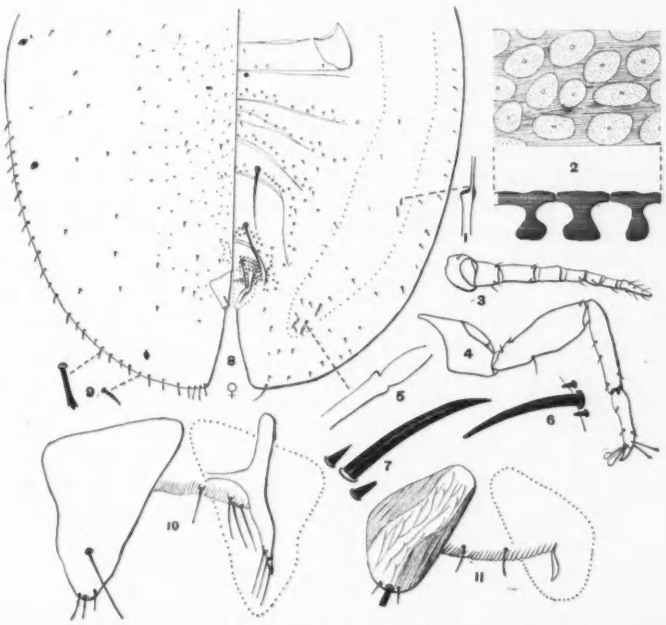

Fig. III. *Saissetia hemisphaerica* (Targ.). 1, small tubular duct; 2, portion of derm of adult female; 3, antenna; 4, leg; 5, large tubular duct; 6, stigmatic setæ of first stage; 7, stigmatic setæ of adult; 8, posterior portion of body of adult; 9, marginal setæ; 10, anal plates of adult; 11, anal plates of first stage.

In the larger, less well-defined genera, such as *Coccus*, *Lecanium* and *Pulvinaria*, where diagnostic characters are especially needed, the anal plates offer little aid.

ANAL RING.

The anal ring of the adult female generally has six or eight large setæ and is perforated by pores. The setæ may all be the

same size or one pair may be smaller than the others, but they vary in size and number within a single genus, so that the anal ring appears to be of use only as a specific character.

The very obscure vulva lies on the ventral side of the body anterior to the anal cleft, in most species it is very difficult to discern.

SPIRACLES AND STIGMATIC DEPRESSIONS.

There are two pairs of thoracic spiracles, the first pair just posterior to the first pair of coxæ and the second pair posterior to the second pair of coxæ. In structure they present a strong, sclerotic plate which bears the spiracular opening. In general they are some distance from the margin (Fig. II, 3, 9), but in a few species this is not the case.

At the body margin, opposite each spiracle, there is usually a depression, the stigmatic depression, which may be very faintly indicated as in *Coccus* and *Saissetia*, very well marked as in *Ceroplastes*, or obsolete as in *Toumeyella*. Stigmatic setæ of variable form and number but usually quite distinct from the marginal setæ occur in these depressions. Leading from the stigmatic depression to the corresponding spiracle there is usually a well-defined furrow which is marked by quinquelocular pores.

The spiracles themselves appear too generalized in form to be of much taxonomic importance, but the stigmatic depressions, the stigmatic setæ and the number and arrangement of the pores in the stigmatic furrow are useful.

MARGINAL SETÆ.

The members of this family usually have about the margin of the body a fringe of setæ of varying form, size and distribution. Some types of marginal setæ are useful in classification. In *Paralecanium* the setæ are flabellate. In *Hemilecanium* the fringe consists of many large, hastate setæ crowded closely together. In *Inglisia* the setæ are of two kinds, some slender and tapering, others stout and clavate. Other genera with distinctive marginal setæ are *Ceroplastodes* and *Filippia*. In *Pseudophilippia* and *Physokermes* the marginal setæ are lacking in the adult.

In many genera the setæ are of a more or less common type, offering characters of but specific importance. The primary

genera, *Coccus*, *Lecanium* and *Pulvinaria*, cannot be separated on the basis of these setæ, there being no correlation between the setæ and any other characters that seem to define the genera.

STIGMATIC SETÆ.

The modified setæ of the stigmatic depressions vary considerably in form and number. There are typically three setæ in each depression, these usually distinctly larger than the marginal setæ and differing from the latter in form. Commonly the three stigmatic setæ are subequal in length, or with the

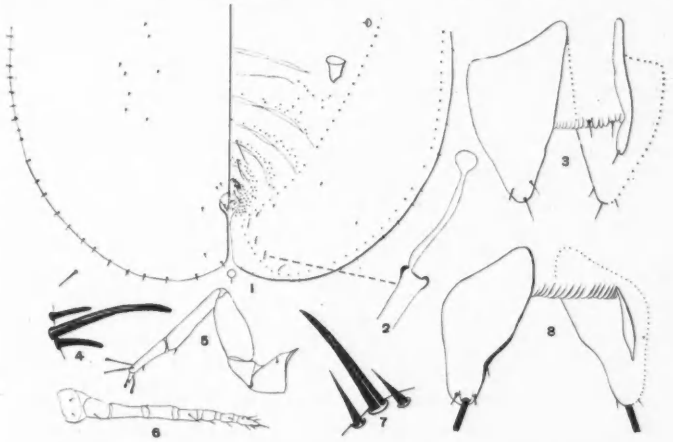

Fig. IV. *Pulvinaria vitis* (Linnaeus). 1, posterior portion of body of adult female; 2, tubular duct; 3, anal plates of adult; 4, stigmatic setæ of adult; 5, leg of adult; 6, antenna of adult; 7, stigmatic setæ of first stage; 8, anal plates of first stage.

central seta longer than the others. Some forms have but two such setæ in each depression, these usually equal in length, or there may be but a single seta. *Ceronema* is distinctive by having six setæ, these rather small, blunt and subequal in length. In *Physokermes* and *Pseudophilippia* the stigmatic setæ are wanting in the adult at least.

In some genera these setæ are not distinguishable in form or size from those of the marginal series, such a condition being found in *Toumeyella*, *Pseudopulvinaria*, *Hemilecanium*, *Inglisia*, *Eriopeltis*, *Takahashia japonica*, *Philephedra*, *Exaeretopus*, *Lecanopsis* and *Cryptostigma*.

As taxonomic characters the stigmatic setæ are only auxiliary and I have found them of no value for generic separation of *Coccus, Saissetia, Lecanium* and *Pulvinaria*. In *Ceroplastes* they are quite distinctive, and in some other forms they are of some aid.

BODY SETÆ.

The typical vestiture of the members of this family consists of a few small, pointed dorsal and ventral setæ, scattered over the body, with two or three about the base of each antenna and usually with three pairs of larger setæ in the perivulvar region. The number and size of the setæ between the antennæ and the number, shape, size and distribution of those on the abdomen all afford good specific characters. For generic characters the body setæ are too general in form, number and arrangement to be of aid except in a few cases. In *Mallococcus* the setæ on the dorsum are quite large, conical and are set in pits. In *Eriopeltis* they are very numerous, large and in the form of a truncate cone.

LARVÆ.

The first stage larvæ (Fig. I) are always active, have well-developed legs and antennæ—the latter usually being six-segmented—have an anal cleft and have the anal plates more or less in the form of lobes and each bearing a long seta at the apex. In all the forms examined the antennæ are six-segmented except in *Toumeyella, Pseudophilippia* and *Takahashia jaliscensis*, where they are five-segmented.

Except in a few genera, the larvæ differ from the adult females in the stouter legs, the reduced antennal segmentation, the general reduction of the number of pores and body setæ, and by the possession of long apical setæ on the anal plates. Exceptions to the general condition appear in the first stage of *Mallococcus, Pseudophilippia* and *Ceronema*, which have 8-shaped pores, and *Cryptes* with a double row of large dorsal setæ.

The first stage of the male can not be distinguished from that of the female. The sexes may first be differentiated when the male puparium is formed.

The general similarity of form of the first stage larvæ throughout the group, together with the frequent difficulty of

obtaining material, makes their taxonomic use difficult. However there are a few genera in which this stage is distinctive and there are specific differences that make the study of the first stage important in any systematic investigation of the group.

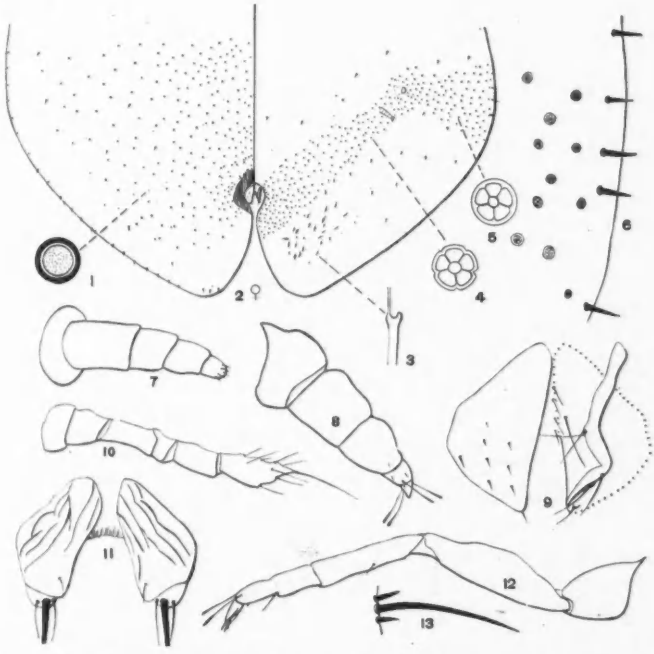

Fig. V. *Toumeyella mirabilis* (Ckll.). 1, tubercle-like pore; 2, posterior portion of body of adult female; 3, tubular duct; 4, 5, quinquelocular pores; 6, section of body margin of adult female with marginal and stigmatic setæ; 7, antenna of adult female; 8, leg of adult female; 9, anal plates of adult; 10, antenna of first stage; 11, anal plates of first stage; 12, leg of first stage; 13, stigmatic setæ of first stage.

STRUCTURE OF THE DERM.

As the adult female reaches maturity the derm usually becomes sclerotic and pigmented. This change sometimes takes place more or less uniformly over the dorsum, the venter remaining membranous. In other cases only a portion of the derm becomes sclerotic, as in *Toumeyella pinicola* where the

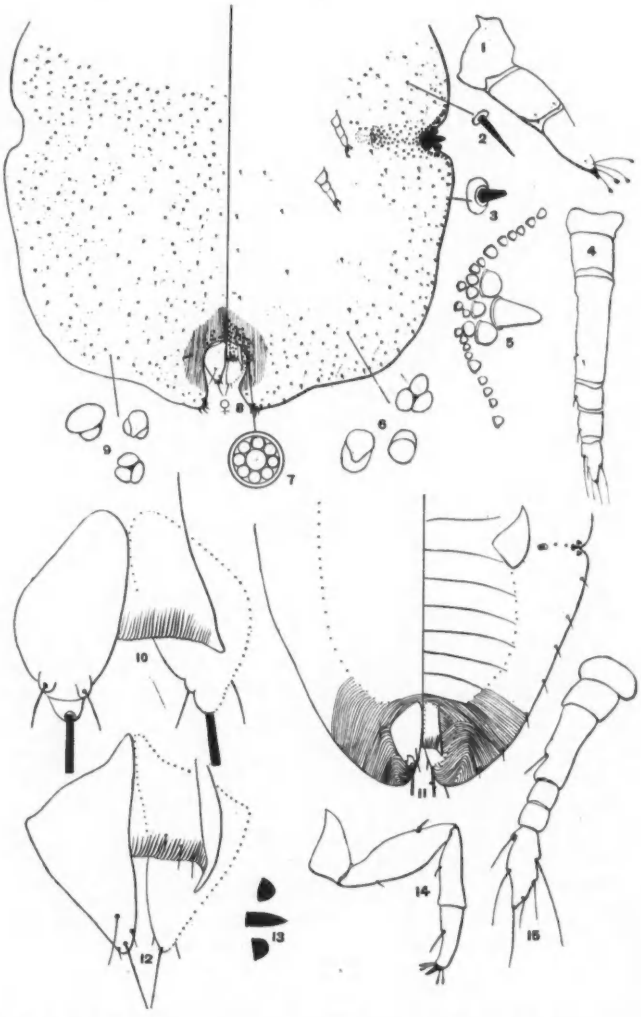

Fig. VI. *Ceroplastes rubens* (Maskell). 1, leg of adult; 2, body seta; 3, marginal seta; 4, antenna of adult; 5, stigmatic setæ of adult; 6, irregular pores of adult; 7, multilocular pore; 8, posterior portion of body of adult female; 9, irregular pores; 10, anal plates of first stage; 11, posterior portion of body of first stage; 12, anal plates of adult female; 13, stigmatic setæ of first stage; 14, leg of first stage; 15, antenna of first stage.

dorsum is membranous except for an area about the anal plates. In some forms the dorsal derm presents the appearance of having many small, cell-like translucent areas, this condition being especially marked in the three common species of *Saissetia*.

Histological sections show that in *Sasissetia hemisphaerica* and in other species as well, this appearance is caused by a varying thickness of the derm, thick and heavily sclerotic areas alternating with thin areas, each of which bears a minute pore (Fig. III, 2), which is the opening of a gland. This condition is widely distributed and its value as an indication of natural relationships is extremely dubious.

In some forms, such as *Mallococcus* and *Eriopeltis*, the derm of the entire body remains membranous.

PORES AND DUCTS.

No thorough investigation of the various wax-secreting glands of the *Coccoidea* has been made. The existing information is consequently very incomplete and the earlier workers mention little except the more conspicuous stellate stigmatic pores, disc pores and submarginal tubercles. Yet, without a doubt, a thorough understanding of these structures will be necessary for the attainment of a satisfactory classification of the group.

Such an understanding can be obtained only by means of a histological study of the structures that underlie these various kinds of pores and ducts and such a study, even for the *Coccidæ* alone, would be worthy of a monograph by itself. For this paper neither the time nor the material for such a study has been available. Consequently, only such information as can be gained from dermal preparations can be presented.

There appear to be three main types of pores and ducts.

1. **Tubular ducts:** Gland openings through cylindrical ducts which bear a smaller prolongation at their inner end.

2. **Sessile pores:** Gland openings through a pore that is sessile in the derm.

3. **Submarginal tubercles:** Elevated tubercles surrounding a double central tube.

1. **Tubular ducts.**

Plate I, Fig. 31 represents a section through a gland of *Lecanium corni* (Bouche). The duct is divided into two parts; a basal portion of relatively large diameter, the inner end of which is reflexed to form a cup, and a distal portion which consists of a relatively very delicate tube that arises from the rim of this cup. The whole tube penetrates into the gland, the delicate tube entering the lumen into which the secretory cell of the gland pours its secretion. From the lumen the wax evidently passes as a fluid through the filament to the basal tube, and thence to the exterior of the body. Modifications of this type occur in other groups of the *Coccoidea*.

In Plate I, Figs. 1-27 are illustrations of the various forms of ducts found in the Coccid genera. There are differences in size, ranging from long, slender dùcts, as in *Hemilecanium* (Fig. 3) and *Inglisia patella* (Fig. 5) to very small forms, as in *Toumeyella* (Fig. 17) and *Cardiococcus* (Fig. 19. The cup may be deep, as in *Ceroplastes* (Figs. 10, 11), or shallow as in *Saissetia hemisphaerica* (Fig. 15). The bottoms of the cups are usually rounded, but they may be cut squarely across, as in *Takahashia japonica* (Fig. 8) or *Lichtensia viburni* (Fig. 7). Some forms have cups that are symmetrical, as in *Pulvinaria* (Fig. 14) or *Saissetia hemisphaerica* (Fig. 15), while in others, as *Mallococcus* (Fig. 12) and *Ceroplastes sinensis* (Fig. 4) the cups are asymmetrical. The inner filament may be very delicate, as in the small ducts of *Saissetia* (Fig. 18), moderately broad as in *Takahashia japonica* (Fig. 8), or nearly as large as the basal part of the duct itself in *Saissetia hemisphaerica* (Fig 15) and *Ceroplastes sinensis* (Fig. 4).

In *Ceronema dryandræ* (Plate I, 28) there occurs a peculiar type of duct which resembles the submarginal tubercles found in some forms and has been so called by Morrison, but its structure is nearer that of a typical tubular duct. It arises from a sclerotic plate that includes a smaller plate which bears a few stout setæ. The opening of the duct is in this smaller plate. The duct bears at its inner extremity a very delicate central filament. This type of duct occurs in a submarginal row around the body and is inter-set with a row of small tubercles of uncertain structure. The first stage of *Ceronema caudata* has ventral submarginal rows of this same type of duct.

Distribution of tubular ducts. All of the thirty-two genera of *Coccidæ* studied possess tubular ducts except only those species which I consider to be true *Coccus*, *Eucalymnatus*, *Paralecanium* (not certain because of poor material), *Cryptostigma*, possibly some species of *Protopulvinaria*, *Lecanopsis brevicornis* and *Toumeyella numismatica*. The ducts occur on either the dorsal or ventral body surfaces, more often the latter, and sometimes on both surfaces in the same species. They are distributed around the anal plates, in submarginal ventral bands and sometimes in the anterior body region, and may be very abundant or only sparsely scattered over the body.

The nature of the secretions produced by the tubular ducts. In *Pulvinaria*, *Filippia* and *Eriopeltis* the tubular ducts seem to be responsible for the production of the ovisac. The bodies of the females of *Eriopeltis* are nearly completely enveloped by the ovisac and the tubular ducts, which occur abundantly on both sides of the body, seem to be correlated with it, for no other type of pore or duct is abundant. The tubular ducts of *Pulvinaria* occur in broad ventral submarginal bands upon the abdomen, which is the correct position for the formation of the ovisac in this genus and there seem to be no other pores from which the ovisac can possibly arise.

However, the presence of numerous tubular ducts does not assure the production of an ovisac, as is evidenced by the species of *Lecanium* and *Saisseta* in which numerous ducts are present in the same position as in *Pulvinaria* but which do not possess an ovisac. It can be concluded therefore that presence or absence of an ovisac depends upon physiological rather than structural peculiarities.

The use of the tubular ducts in taxonomy. The possibilities of use of any one structure throughout a group are limited, for a structure which is constant in one group may break down completely in another. One type of tubular duct may be constant throughout a genus, as in *Pulvinaria* which has a duct with a short basal tube of medium breadth surmounted by a shallow sclerotic cup and bearing a long, slender filament (Plate I, Fig. 14). In all the species that I consider to be true *Lecanium*, except *L. persicae*, the tubular ducts are rather short and stout with a shallow, bulging, non-sclerotic cup and a short, slender filament (Plate I, Fig. 13).

The only morphological characters that I have been able to find to separate *Pulvinaria* from *Lecanium* are this difference in the ducts and the presence or absence of a free tibio-tarsal articulation. In *Ceroplastes* there are at least two types of tubular ducts (Plate I, 4, 10) in the different species. In *Ceronema dryandræ* there are three distinct types of tubular ducts, a condition that represents the extreme in the development of these structures. In general it may be said that the possibilities of taxonomic use of the tubular ducts are limited, but in some cases they are of considerable value, so that in a systematic study they may not be ignored.

Relation of the tubular ducts found in the Coccidæ to those found in other forms. In Plate I, Figs. 21-25 are drawings of several tubular ducts found in other groups. *Eriococcus* (Fig. 22), *Lecaniodiaspis* (Fig. 21), *Olliffiella* (Fig. 20) and *Kermes* (Fig. 23) have ducts of the same general type as those of the *Coccidæ*, that is with a cup and a filament arising from its rim. In *Kermes cockerelli* (Fig. 23) the shape of the ducts is peculiar, the cup being very deep and narrow, but it is essentially of the same type as the others. No special significance can be attached to this similarity of the ducts until other characters of the two groups have been investigated.

Pollinia ovoides (Fig. 25) and *Asterolecanium variolosum* (Fig. 24) possess crooked, irregular shaped ducts without true cups. The curve at one point may represent the further development of the condition found in the large tubular ducts of *Saissetia hemisphaerica* (Fig. 15) in which the filament has become so enlarged that the cup remains merely as a sort of thumb on one side.

2. **Sessile Pores.**

There are a number of distinct types in this group and a discussion of each will be given.

Multilocular pores. These are round pores (Plate II, 18, 19) with from six to twelve loculi and are found in nearly all the groups of scale insects. They are present in all the *Coccidæ* examined except *Ceronema*, *Cardiococcus*, *Pseudopulvinaria*, *Pseudophilippia*, *Neolecanium*, *Toumeyella numismatica*, *T. mirabilis*, *T. pinicola*, *T. pini* and *T. turgida*. They occur on the ventral side of the abdomen in transverse rows and around the anal region, except in *Takahashia japonica* where they are

scattered on both sides of the body and in *Lecanopsis brevicornis* where they occur along the margins of the body and to some extent on the dorsum. In the available specimens of *Physokermes*, broad bands of these pores have replaced the usual quinquelocular pores in the stigmatic furrows. The wide distribution and generalized location of these pores reduce them to usefulness only in specific classification. In the ovisac-producing species examined it hardly seems probable that these pores are responsible for the production of the sac, they being inadequate in numbers. When soft young adults of *Saissetia* or *Lecanium* are removed from their hosts, bands of white powdery wax are visible on the abdomen and around the anal plates, which probably come from these pores.

Quniquelocular or stellate pores (Plate II, 22). These are round pores with only five loculi which surround a central space, the whole having a stellate appearnce. They occur in several groups of scale-insects and are found in all the species of the *Coccidæ* that I have examined except in *Physokermes*, where they are replaced by multilocular pores. With a few exceptions this type of pore is confined to the stigmatic furrows and the region about the spiracular plates, as in *Hemilecanium imbricans*, or it may occur about the bases of the stigmatic setæ as in *Mallococcus*. In *Toumeyella*, *Neolecanium*, and *Pseudophilippia* these pores replace the multilocular type and extend over the venter of the abdomen.

The available species of *Cardiococcus* have a few ventral pores of this type around the anal region. *Exaereiopus longicornis* has narrow bands of large quinquelocular pores all around the body, in addition to the stigmatic bands. In *Pseudopulvinaria* there are such pores all over the dorsum.

I have seen no case in which these pores appear to be responsible for the production of the ovisac, so their only secretions are probably the powdery bands of white wax such as those which occupy the stigmatic furrows. The general appearance of these pores in the stigmatic furrows is nearly constant throughout the group. Exceptions to this condition may be utilized in classification. The species of *Toumeyella*, *Neolecanium* and *Pseudophilippia* are evidently related, on the basis of various characters, and this relationship is further indicated by the general distribution of these pores over the ventral side of the abdomen.

Round, tubercle-like pores (Plate I, 30). This type of pore presents a sclerotic ring surrounding a center with many perforations which in vertical section is more or less dome-shaped. I have found these pores only on the dorsum, where there is usually a group just cephalad of the operculum and sometimes a row along the mid-line of the dorsum.

They are present in a wide range of forms including *Saissetia, Pulvinaria, Lecanium, Neolecanium, Toumeyella, Cardiococcus, Hemilecanium, Eriopeltis, Philephedra, Paralecanium, Exaeretopus, Pseudophilippia* and *Takahashia jaliscensis*. In *Toumeyella* they occur in a group just cephalad of the operculum, or scattered over the central portion of the dorsum or widely distributed over the posterior region of the dorsum. *Physokermes* has pores of this type scattered over the entire dorsum.

This type of pore is in general typical of this family, although it occurs also in some species of *Aclerda*, at least. I have looked for it especially in the Eriococcid and Asterolecaniid genera but have not found it there. As a generic character they are apparently of but secondary importance, but their number and distribution have proved useful for specific separation in a number of cases.

There is no obvious secretion from these pores and their function is doubtful.

Simple, round pores (Plate II, 23). This type of pore consists of merely a simple ring. It is usually somewhat smaller than the multilocular and quinquelocular pores and I have always found it on the dorsum, except in *Cardiococcus fossilis* where it is ventral. There are usually only a few of these pores scattered over the dorsum, as in *Coccus, Saissetia, Pseudopulvinaria, Luzulaspis, Lecanopsis brevicornis* and a few species of *Lecanium* and *Pulvinaria*. In *Hemilecanium imbricans* the dorsum is thickly beset with them, while in *Cryptostigma ingæ* there are two sizes of them, both with a heavy outer ring, scattered over the dorsum. *Cardiococcus fossilis* has small, round ventral pores which are most abundant in the marginal areas; occasionally two of these are approximate and form an 8-shaped pore. In *Mallococcus* also, round pores and 8-shaped pores occur together and this suggests a possible origin of the latter type (Plate II, 4). Evidence as to the secretions from these pores is inconclusive.

The occurrence of a few of these pores is common to a number of genera and therefore only unusual abundance, as in *Hemilecanium* and *Cryptostigma*, or restriction in distribution as in *Cardiococcus*, is of taxonomic usefulness.

Eight-shaped pores. In the available material of this group I have found a number of species with 8-shaped pores of several types. I have classified these pores into five groups. I have also compared them with the pores of similar appearance in the Asterolecaniids and species.

1. Simple, without filament or tube (Plate II, 2). Very small pores having two equal halves which are separated by a narrow space and the centers of which are granulate. I have found this type of pore in *Cardiococcus fossilis*. It is apparently formed merely by the close approximation of two simple pores. A few pores of this type are present on the dorsum of the first stage of *Mallococcus sinensis*.

2. Simple, with tube. Very small pores having two equal halves with a granular appearance, separated by a narrow space and borne at the inner end of an invaginated tube. I have found this type of pore in two species. In *Mallococcus sinensis* (Plate II, 4) there are many scattered over the dorsum of the adult female. In the first stage of *Ceronema dryandræ* (Plate II, 6) there are a number of such pores on the dorsum.

3. With a heavy outer ring, a sclerotic cross-bar and without a tube (Plate II, 3) I have found this type of pore only in *Takahashia jaliscensis*, in which they are small and scattered over the dorsum.

4. With a heavy outer ring, a sclerotic cross-bar and a tube (Plate II, 5). These are small pores borne at the inner end of an invaginated tube. I have found them only in *Pseudophilippia quaintancei*, where they are abundant on the dorsum and are probably responsible for the profuse cottony secretion which is characteristic of this species.

5. With the two parts of unequal size, separated by a narrow space and without a tube (Plate II, 1). The smaller part is granular in appearance and the larger has a heavily sclerotic ring surrounding the clear center. Sometimes the larger portion is divided into two parts, giving the pore a trilocular appearance. I have found this type of pore only in *Cardiococcus fossilis* and *C.* (*Inglisia*) *castilloæ*, where they are arranged in a single row along the mid-line of the dorsum from

the anal plates to the anterior margin of the head and also in a single row about the margin of the body.

The presence of 8-shaped pores has been regarded as the most distinctive character of the Asterolecaniids, so that any consideration of these pores as they occur in the *Coccidæ* must include a comparison of the two groups. In the Asterolecaniids (Plate II, 20) these pores are composed commonly of two equal parts separated by a space and not borne on an invaginated tube, this being the typical form. I have found no 8-shaped pores in the *Coccidæ* that are of exactly this character although those of *Cardiococcus fossilis* (Plate II, 1) bear some resemblance to this, but have two parts of unequal size and different structure. In *Cerococcus* (Plate II, 10) these pores are of a slightly different form. They are of varying size, are composed of two equal parts with heavily sclerotic outer rings, which are separated by a narrow space, and are borne at the inner end of a very short tube. In the available material of the *Coccidæ* I have found no pores of this form.

In the Asterolecaniid, *Callococcus pulchellus*, the adult female has 8-shaped pores with a sclerotic outer ring (Plate II, 17) and a cross-bar and borne at the inner end of an invaginated tube. In the first stage of this species the pores are of the same type except that they are slightly elevated (Plate II, 15) instead of invaginated. Morrison[3] has represented these pores as bearing small filaments arising from their centers, but careful study with an oil immersion lens has not revealed such structures in the material that I have examined. The 8-shaped pores of *Pseudophilippia quaintancei* (Plate II, 5) are very similar to those of the adult of *Callococcus pulchellus*.

In *Eremococcus pirogallis* (Plate II, 16) there are 8-shaped pores with a sclerotic ring and a cross-bar, the whole enclosed within another ring and slightly elevated. Morrison has figured these as bearing delicate filaments but I have been unable to find these structures. However, in the first stage of three species I have found these 8-shaped pores with filaments and these are figured as follows, *Lecaniodiaspis tesselatus* (Plate II, 12), *Cerococcus quercus* (Plate II, 13), *Pollinia ovoides* (Plate II, 11).

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[3]Morrison, H. Proc. U. S. Nat. Mus. 60: Art. 12: 32–5, f. 10, (1922).

The pores of *Takahashia jaliscensis* are very similar to those which occur in *Eremococcus*, except that they lack the outermost ring. The 8-shaped pores in *Lecaniodiaspis sardoa* and *Cerococcus bryoides* are slightly irregular in shape and seem to consist of two simple pores joined by a connecting membrane (Plate II, 9, 10).

In conclusion, it can be said that in the material examined I found no 8-shaped pores in the *Coccidæ* that were exactly the same as those in the Asterolecaniids, although no final conclusion can be drawn until these results have been checked by histological study of the exact structure of the glands.

In the Eriococcids examined, this including material of *Eriococcus*, *Kermes* and *Olliffiella*, I have found 8-shaped pores only in *Olliffiella cristicola* (Plate II, 8) which has such pores, of fairly large size, scattered over the dorsum. These seem to be composed of small pores arranged on an 8-shaped plate. I have seen no such pores elsewhere.

I have attempted to show that while 8-shaped pores occur in the *Coccidæ*, not all such pores are identical in structure and that various forms occur both in the Coccids and the Asterolecaniids. A final understanding and classification of these structures waits upon extended histological study. I have presented all that I have been able to learn from dermal preparations.

Pore plates. In a number of scale insects there occur pores which are aggregated into pore plates, to which the term *cribriform plates* has been applied.

In *Hemilecanium imbricans* (Plate II, 34) there are four large pore plates on the dorsum that are composed of an aggregation of many small pores with thick walls which are crowded together so closely that the whole has the appearance of a plate punched full of holes.

Inglisia patella (Plate II, 33) bears two large dorsal plates just cephalad of the anal plates, which are composed of many round or oval pores loosely grouped together.

Cryptostigma ingæ (Plate II, 32) bears a large, crescent-shaped pore plate dorsally at each stigmatic depression. These plates bear many small, multilocular pores and from each there arises in life a long pencil of wax.

Toumeyella numismatica (Plate II, 31) bears small pore plates consisting of from two to eight pores which seem to be

made up by the aggregation of separate, thick-walled pores. I have found such plates only in this species.

Several species of *Paralecanium* including *luzonicum*, *expansum* and *cocophyllæ* have cribriform plates on the venter of the abdomen, but the available preparations are too poor to permit study.

In *Lecanopsis brevicornis* and *L. formicarum* there is a large, circular plate surrounding each spiracle and bearing small, multilocular pores.

Miscellaneous pores. 1. Irregular pores (Plate II, 21, 26), made up of two, three or four parts and found thickly scattered over the dorsum of nearly all the species of *Ceroplastes* and around the ventral margin in several species of the same genus. These pores are probably responsible for the typical waxy covering of the species of this genus.

2. Trilocular pores (Plate II, 27, 29), which are dorsal pores found only in the genus *Ceroplastes*, egg-shaped as in *C. sinensis* (Fig. 27) or circular as in *C. irregularis* (Fig. 29). They are divided into three parts and the walls present the appearance of a Y. They replace, in *Ceroplastes sinensis* and *C. irregularis*, the irregular pores mentioned above and probably have the same function.

3. Trilocular, oval pores (Plate II, 28), which are small ventral pores, divided transversely into three parts. They are found in several species of *Ceroplastes*, usually forming marginal bands. I have found this type of pore only in *Ceroplastes* and regard it as typical of the genus.

4. Small round pores with duct (Plate II, 24). I have found these pores only in *Neolecanium herrerœ*, where they are numerous on the venter. I have no information as to their possible occurrence in other species of this genus.

5. In *Coccus bicruciatus* I found very small, round, thick-walled pores of uncertain structure, arranged in a double row of six groups along the mid-line of the dorsum. They are so small that I was unable to determine their structure.

3. **Submarginal tubercles.** (Plate I, 29).

These are round tubercles surrounding a central invaginated tube and occur about the dorsal margin in a number of the *Coccidæ*. Their structure is peculiar, the derm being invaginated

to form a tube, which is reflexed to form a tube within the first, the innermost tube opening at the surface. They are usually quite large and in most forms there are from five to seven pairs. The following genera have pores of this type:

Coccus; occurring in nearly all species, fairly large, five to seven pairs.

Saissetia; small in *hemisphaerica* and *oleæ*, large in *nigra*, five to seven pairs in each species.

Lecanium; found only in *persicæ* and *corni* of the species examined. *L. persicæ* has twenty to twenty-five large tubercles. In material that has been referred to *L. corni* I have found these tubercles on specimens from the following hosts, *Quercus agrifolia*, *Q. lobata*, *Pasania densiflora*, *Pickeringia*, *Arbutus menziesii*, *Ceanothus*, willow, *Adenostoma* (tubercles occasional) and *Heteromeles* (occasional). In what may be regarded as typical *L. corni* they are lacking.

Pulvinaria; present in a few species, four to eight, rather small.

Hemilecanium imbricans; with many large tubercles set close together, thirty to thirty-five on each side of the body.

Ceronema dryandræ; without tubercles as here described but with large ducts, previously dealt with, which have been confused with these.

The secretion of these tubercles is in some cases at least a glassy thread. The tubercles are of no value in separating the four closely related and important genera, *Coccus*, *Saissetia*, *Pulvinaria* and *Lecanium*.

Diagnoses of Certain Important Genera.

Following a study of thirty-two important genera of the *Coccidæ*, I have drawn up a summary of the generic characters of the adult female and the first stage larva where the latter was available. I have attempted to arrange the genera in natural groups with, however, but little success. Thirteen of the genera can be aggregated into three groups, but the remainder seem to stand each by itself. A study of all the genera of the family may reveal relationships that will make attempts at grouping more successful, but from the material that I have worked with I can make no attempt to divide the family into subfamilies or tribes.

The three groups that I have been able to recognize are as follows.

1. *Coccus* and related forms including *Eucalymnatus*, *Lecanium*, *Proto-pulvinaria*, *Pulvinaria* and *Saissetia*.

2. *Toumeyella*, together with *Neolecanium* and *Pseudophilippia*.

3. *Exaeretopus*, with *Parafairmairia*, *Philephedra* and *Luzulaspis*.

The remaining genera not included in these groups are arranged alphabetically.

1. The group of **Coccus.**

ADULT FEMALE: With or without ovisac; with well-developed legs and antennæ; with shallow stigmatic depressions bearing nearly always three stigmatic setæ; marginal setæ variable in form but usually more slender and shorter than the stigmatic setæ; anal region without hypopygial setæ. Pores and ducts as follows: (1) multilocular pores on the venter about the anal region and usually in transverse rows across the abdomen; (2) quinquelocular pores in the stigmatic furrows only; (3) submarginal tubercles occurring only in some species; (4) tubular ducts present except in *Coccus* and *Eucalymnatus*.

Genus **Coccus,** Linnaeus.

TYPE: *Coccus hesperidum* Linnaeus.

SPECIES EXAMINED: *acutissimus* (Gr.), *aequale* (Gr.), *bicruciatus* (Gr.), *caudatus* (Gr.), *frontale* (Gr.), *longulus* (Douglas), *mangiferæ* (Gr.), *viridis* (Gr.).

ADULT FEMALE: (Fig. II, 9) naked or covered only with a thin film of secretion; antennæ well-developed, slender, 6-8-segmented, third and fourth segments usually the longest; legs well-developed, without free tibio-tarsal articulation and with merely a transverse septum between the tibia and tarsus or with a small articular process, but apparently with no free movement of the joint (Fig. II, 5); anal cleft relatively short compared to the body length; anal operculum quadrate with cephalo-lateral and caudo-lateral margins equal or nearly so in length and forming rather sharp angles, with one or more small discal setæ near the apex of each plate; with no hypopygial setæ (Fig. II, 7); spiracles normal; marginal setæ variable, but always more slender than the stigmatic setæ; stigmatic setæ three, the middle usually longer than the other two; stigmatic depressions slightly indicated; tubular ducts apparently lacking; multilocular pores (Fig. II, 8) around the ventral anal region; quinquelocular pores in narrow bands in the stigmatic furrows; a few simple, round pores scattered over the dorsum; submarginal tubercles (Plate I, 29), present, 5-7 on each side of the body.

FIRST STAGE: (Fig. I, 4) with antennæ 6-segmented; legs normal; stigmatic setæ 3, with the middle one longer than the others; marginal

setæ short, small; body setæ lacking except near the base of each antenna and in the ventral abdominal region; anal plates not protruding beyond apex of body and not reticulated; quinquelocular pores present in stigmatic furrows; anal ring with 6 hairs. Material examined, *C. hesperidum* only.

NOTES: The generic characters of *Coccus* have never been well-defined and many species of uncertain relationships have been placed in the genus only because it was a convenient pigeon-hole. It has been separated from *Lecanium* by the flatness of the adult females, which are supposed to be at the most only slightly convex, but such a distinction is worthless.

I have tried to find some structural characters that can isolate the genus, and from the species studied I have been led to conclude that the apparent absence of tubular ducts, the small number of multilocular pores, the rather quadrate anal operculum and the character of the marginal setæ, which are usually rather short, pointed or moderately fimbriate, rarely broadly fimbriate, distinguish the true species of *Coccus*.

I would include *aequale*, *elongatus*, *frontale*, *hesperidum*, *longulus*, *pseudomagnoliarum* and *viridis* as typical species of the genus.

C. acuminatus and *C. mangiferæ* are closely related to *Protopulvinaria pyriformis* Ckll. and I would place them in the latter genus because of the similarity of body form, the long, narrow operculum, the deep anal cleft running far into the body and the short, broadly fimbriate marginal setæ.

C. acutissimus and *C. bicruciatus* apparently do not belong in *Coccus*, but until I have more material available I will not attempt to relocate them.

Genus **Protopulvinaria** Ckll.

TYPE: *Protopulvinaria pyriformis* Ckll.

SPECIES EXAMINED: *P. pyriformis* Ckll., *Coccus mangiferæ* Gr., *Coccus acuminatus* Sign.

ADULT FEMALE: Broadly pyriform, more or less acuminate in front; body naked or with a very narrow fringe of cottony secretion; anal cleft long, extending nearly to the center of the body; operculum long and very narrow, the cephalolateral margins much longer than the caudolateral; antennæ long and slender, 7-8-segmented; legs long and slender; marginal setæ very short, broadly fimbriate, set very close together; stigmatic setæ 3, the middle one much longer than the others; stigmatic depressions slight; marginal tubercles 5-7 pairs; anal ring with 6 hairs.

NOTES: Cockerell separated this genus from *Coccus* by the presence of a narrow fringe of cottony secretion surrounding the body of the female after oviposition. This is not an ovisac, as in *Pulvinaria*, for the eggs are concealed beneath the body of the female. Green included his *longivalvatus* here for the same reasons. I would add the other species mentioned although they do not possess the secretion.

Genus **Eucalymnatus** Cockerell.

TYPE: *Lecanium tessellatum* Sign.

SPECIES EXAMINED: The genotype only.

ADULT FEMALE: Elongate, irregularly oval, broadly rounded posteriorly, narrower in front; dorsal area of mature individuals divided into many irregular plates in a roughly symmetrical pattern: in all other respects possessing the same characteristics as the genus *Coccus*.

NOTES: Cockerell established *Eucalymnatus* as a subgenus of *Lecanium*, and it was afterward raised to generic rank. It was established and has been maintained solely because of the striking appearance of the adult female due to the division of the derm into plates.

I have studied several young adult females before the hardening and tessellating of the derm had begun and when the structural characters could be clearly seen. I see no reason for maintaining the genus as distinct from *Coccus* or at the most as anything more than a subgenus.

Genus **Saissetia** Deplanches.

TYPE: *Lecanium hemisphaericum* Targ. (Fig. III).

SPECIES EXAMINED: *S. hemisphaerica* (Targ.), *oleæ* (Bern.), *nigra* (Nietner).

ADULT FEMALE: (Fig. III, 8) Body naked; derm of the dorsum at maturity becoming heavily sclerotic, with many thin areas that show as spots in dermal preparations; antennæ slender, 6-8-segmented; legs clear well-developed, tarsus with a conspicuous outward flexure and with a sclerotic articular process between it and the tibia, or tibia and tarsus separated by a simple transverse septum; anal cleft relatively short; operculum variable in shape, with a single large discal seta on each plate (Fig. III, 10); no hypopygial setæ; marginal setæ slender, pointed or moderately fimbriate at the apices, much more slender than the stigmatic setæ; stigmatic depressions slight, with three setæ of which the middle one is much the longest; spiracles normal; multilocular pores on the ventral side, grouped in the anal region and extending in transverse rows across the abdomen; quinquelocular pores confined to narrow bands in the stigmatic furrows; tubular ducts of two kinds,

both ventral, one with a small, short basal duct, a shallow, sclerotic symmetrical cup and a delicate inner filament (Fig. III, 1) the other a broad basal tube, a shallow cup and a filament which is nearly as broad as the basal duct (Fig. III, 5), this latter present only in *hemisphaerica;* tubercle-like pores (Plate I, 30) large, present on the dorsum just anterior to the anal plates in *oleæ* and *nigra*, not present in *hemisphaerica;* submarginal tubercles (Plate I, 29) 5-7 in each species.

First Stage: Antennæ 6-segmented; legs normal; stigmatic setæ 3, the central one long, the others short; margin with short, slender setæ; no body setæ except near the antennæ and in the posterior ventral body region; anal plates not protruding beyond the apex of the body; stigmatic furrows with a few quinquelocular pores; anal ring with 6 hairs.

Material Examined: *S. hemisphaerica*, *S. nigra.*

Notes: This genus has usually been characterized by the convex form of the adult females and the clear areas of the derm, the latter character being regarded as definitive. This is misleading, however, for there are a number of species in the family that have this characteristic clearly developed but that do not belong to this group. *Saissetia* may be separated from *Pulvinaria* and *Lecanium* by the presence of the large discal setae on the anal plates, and by a different form of tubular duct.

Genus **Lecanium** Illiger

Type: *Coccus tiliæ* Linnaeus or *Coccus coryli* Linnaeus. *Tiliæ* is possibly a synonym of *coryli*, in which case *coryli* has priority.

Species Examined: *L. caryæ* (Fitch), *cerasorum* Ckll., *corni* (Bouche) *coryli* (L.) (= *capreæ* (L.)), *discrepans* Gr., *excrescens* Ferris, *formicarii* Gr., *impar* Ckll., *nigrofasciatum* Perg., *opimum* Gr., *persicæ* (Fab.), *pruinosum* Coq., *prunastri* (Fonsc.).

Adult Female: Naked or at the most with a rather thin covering of powdery wax; antennæ well-developed, 6-8-segmented; legs well-developed, without a free tibio-tarsal articulation, the tibia and tarsus usually separated by a simple transverse septum; anal cleft relatively short; anal plates of no distinctive type, but without discal setæ; hypopygial setæ lacking; spiracles with no distinctive characteristics; marginal setæ variable in form, usually distinctly more slender than the stigmatic setæ but sometimes not so; stigmatic setæ 3, usually conical, the three subequal in length or with the middle one slightly the largest; multilocular pores ventral, grouped in the anal region and extending up the abdomen in transverse rows in some species; quinquelocular pores present only in narrow bands in the stigmatic furrows; tubular ducts (Plate I, 13) ventral with small, short basal tube, thin-walled cups and slender filament, (*persicæ* has ducts that are larger and with wide filament, resembling the larger ducts of *Saissetia hemisphaerica*); simple pores (Plate II, 23) are present in several species, scattered over

the dorsum; tubercle-like pores (Plate II, 30) occurring in several species in a group cephalad of the operculum or extending cephalad along the mid-dorsal line; sub-marginal tubercles present only in *persicæ* and *corni;* body setæ usually confined to 3 ventral pairs just cephalad of the anal region and 2 or 3 around the base of each antenna and occasionally short, conical setæ along the mid-dorsal line as in *L. corni.*

FIRST STAGE: Antennæ 6-segmented; legs normal; stigmatic setæ 3, equal or unequal; margin with short setæ; body setæ lacking except near antennæ and in ventral abdominal region; anal lobes sometimes protruding beyond apex of body, sometimes reticulate; stigmatic furrows with quinquelocular pores; anal ring with 6 setæ.

MATERIAL EXAMINED: *L. excrescens, formicarii, opimum.*

NOTES: The absence of a free tibio-tarsal articulation and the characteristic tubular ducts are characters that seem to separate this genus from *Pulvinaria.* The anal plates lack the large discal seta of *Saissetia.*

Genus **Pulvinaria** Targioni-Tozzetti.

TYPE: *Coccus vitis* Linnaeus.

SPECIES EXAMINED: *P. acericola* (Walsh & Riley), *aurantii* Ckll., *bigeloviæ* Ckll., *camelicola* Sign., *cupaniæ* Ckll., *ehrhorni* King, *floccifera* (Westwood), *mesembryanthemi* (Vall.), *occidentalis* Ckll., *peninsularis* Ferris, *psidii* Maskell, *rhois* Ehrh., *tinsleyi* King, *urbicola* Ckll., *vitis* (L.).

ADULT FEMALE (Fig. IV, 1): Naked until the beginning of oviposition, when a white, cottony ovisac is secreted from the ventral abdominal region, the body is often tilted up by the ovisac but is never enveloped by it; derm of the dorsum remaining membranous throughout life or, in most cases, becoming more or less sclerotic; antennæ well-developed, 6-8-segmented; legs well developed, with a free tibio-tarsal articulation, a heavily sclerotic articular process of the tarsus interlocking with the tibia (Fig. IV, 5); anal cleft relatively short; operculum of no distinctive form, without discal setæ; hypopygial setæ lacking; marginal setæ variable but always more slender than the stigmatic setæ; stigmatic depressions slight; stigmatic setæ 3, the middle one being considerably longer than the others (Fig. IV, 4); body setæ confined to 3 pairs of long ventral abdominal setæ and several between the bases of the antennæ; multilocular pores ventral, grouped in the anal region and in transverse bands on the abdomen; quinquelocular pores confined to narrow bands in the stigmatic furrows; tubular ducts large or small, with short basal tube, shallow, thick-walled, symmetrical cup and long, delicate filament, these are distributed in broad, sub-marginal, ventral bands; simple pores found on the dorsum of a few species; tubercle-like pores on the dorsum in several species; sub-marginal tubercles found in a few species, 4-8 pairs.

FIRST STAGE: Antennæ 6-segmented; legs normal; stigmatic setæ 3; margin with a few short setæ; body setæ lacking except near the base of each antenna and on the venter of the abdomen; anal lobes pro-

truding beyond apex of body or not and reticulated or non-reticulated; stigmatic furrows with a few quinquelocular pores; anal ring with 6 setæ. Material examined: *P. vitis, occidentalis* and an unidentified species.

NOTES: *Pulvinaria* has conventionally been separated from related genera by the presence of an ovisac in the adult female and earlier writers state that in structural characters there is nothing which will distinguish it from *Lecanium*. On the basis of the available material I believe that these two genera can be separated by the character of the legs and the tubular ducts, the free tibio-tarsal articulation and the form of the tubular ducts of *Pulvinaria* contrasting with the immovable division and a different duct form in *Lecanium*. The broad bands of ventral tubular ducts probably produce the ovisac in *Pulvinaria*, but in *Lecanium*, although the ducts are equally numerous there is no ovisac. It seems reasonable to conclude that the difference is physiological.

2. The group of **Toumeyella.**

To this group there belong three so-called genera, *Toumeyella*, *Neolecanium* and *Pseudophilippia*. Personally I regard these as constituting but a single genus, which might possibly be divided into subgenera.

ADULT FEMALE: Legs and antennæ greatly reduced but retaining their parts; anal plates very large, usually quadrate, with discal setæ; hypopygial setæ present; stigmatic depressions obsolete; marginal and stigmatic setæ small and inconspicuous or entirely lacking; stigmatic furrows with broad bands of quinquelocular pores, these pores also distributed over the venter to the anal region; tubercle-like pores numerous on the dorsum.

Genus **Toumeyella** Ckll.

TYPE: *Lecanium mirabilis* Ckll.

SPECIES EXAMINED: *Toumeyella cerifera* Ferris, *liriodendri* (Gmelin), *mirabilis* (Ckll.), *pini* King, *pinicola* Ferris, *turgida* Ckll.: *Neolecanium hererræ* Ckll. and *N. imbricatum* (Ckll.): *Pseudophilippia quaintancei:* Ckll: *Lecanium numismaticum* Pettit and McDaniel.

ADULT FEMALE: (Fig. V, 2) Naked, or with a thin, glassy test or with the dorsum thickly covered with cottony secretion; not secreting an ovisac except in the case of *T. cerifera;* tubular ducts small, present in small numbers around the anal region on the venter; quinquelocular pores (Fig. V, 2, 4, 5) extremely abundant, arranged as described for the group; tubercle-like pores more or less abundant on the dorsum, variously

arranged (Fig. V, 1, 2); in addition to these three types of pores special types occur in certain species as follows, simple pores (Plate II, 3) on the dorsum in the anal region of ***pini*** and ***turgida***, multilocular pores on the venter in the anal region and in tranverse rows in ***cerifera;*** small pores borne at the apex of a short duct (Plate II, 24) in ***herreræ***; 8-shaped pores (Plate II, 5) borne at the inner extremity of a duct in ***quaintancei;*** pore plates (Plate II, 31) in ***numismatica;*** anal ring with 6-8 setæ.

FIRST STAGE: Antennæ 5-segmented (Fig. V, 10); legs normal; stigmatic setæ 3, the middle one sometimes very long; marginal setæ few; body setæ few; stigmatic furrows with a few quiquelocular pores; other types of pores variable; anal ring with 6 setæ. Material examined: ***cerifera, liriodendri, mirabilis, quaintancei, turgida*** and an unidentified species.

NOTES: A complete understanding of the relationships of these species can only come with an examination of a wider range of forms, but I regard them as representing a single genus.

3. The group of **Exaeretopus.**

To this group there belong *Exaeretopus*, *Parafairmairia*, *Philephedra*, and *Luzulaspis*.

The female is long and slender; the derm remaining more or less membranous at maturity; antennæ and legs well-developed, the latter with free tibio-tarsal articulation; stigmatic depressions obsolete or vestigial; tubular ducts on both dorsum and venter, multilocular pores around anal plates and in abdominal rows.

Genus **Exaeretopus** Newstead.

TYPE: *Exaeretopus formiceticola* Newstead.
SPECIES STUDIED: *E. longicornis* (Gr.).

Adult female covered at gestation with a felted sac. In old females the posterior half of the abdomen is often sclerotic and minutely wrinkled. Antennæ long, 8-segmented; legs well-developed, with free tibio-tarsal articulation, anterior tarsus appearing dimerous because of an infolding in the derm; anal cleft relatively short; anal plates with no specially distinctive characters; hypopygial setæ absent; marginal setæ slender, trichiform; stigmatic setæ distinct from the marginal setæ or not so; stigmatic depressions obsolete; body setæ, small short, sometimes with longer trichiform setæ between the antennæ and in rows upon the ventral surface of the abdomen; tubular ducts of medium size, with very shallow cup which is barely indicated, so that the duct appears to be cut squarely across, filament delicate, the ducts numerous on both dorsum and venter; quinquelocular pores large, arranged in narrow lateral bands around the body and in narrow stigmatic bands; multilocular pores on the ventral side of the abdomen; tubercle-like pores small, a few along the mid-line of the dorsum.

NOTES: No material of the genotype, *E. formiceticola*, was available for examination and so I have been forced to rely upon the literature for information concerning this species. The genus was originally based upon the presence of the sac at maturity and the supposed dimerous condition of the anterior tarsi. Green has recently shown that this supposed condition of the tarsus does not hold, there being no actual articulation.

E. longicornis, which I have examined, agrees with Green's re-description of *formiceticola*, except that it lacks stigmatic setæ and the wrinkled, sclerotic condition of the abdomen, which appears in the adult female of the latter. I have therefore based my diagnosis of the genus principally upon *E. longicornis*.

Genus **Philephedra** Ckll.

TYPE: *Pulvinaria ephedræ* Ckll. The only included species.

SPECIES EXAMINED: The genotype.

ADULT FEMALE: Front part of the body in life covered by a thick square patch of secretion, posterior margin fringed with secretion and with irregular patches arranged in three longitudinal bands on the dorsum; antennæ very long and slender, 8-9-segmented; derm more or less membranous at maturity; anal plates with no distinctive features; marginal setæ short, spike-like, set closely together; stigmatic setæ not distinct from marginal setæ and stigmatic depressions obsolete; body setæ few, a few small setæ near the bases of the antennæ and three pairs of longer setæ on the venter of the abdomen; multilocular pores, few, around the anal region and in transverse bands on the ventral side; tubercle-like pores present on the dorsum in considerable numbers and extending along the mid-line of the body; many tubular ducts on both dorsal and ventral sides of the body, but more on the dorsum and probably responsible for the patches of secretion; quinquelocular pores in narrow bands in the stigmatic furrows.

Philephedra ephedræ is one of the largest forms in the family, reaching a length of 7-8 mm. and a width of 3-4 mm.

Genus **Parafairmairia** Cockerell.

TYPE: *Fairmairia bipartita Signoret.* The genus includes only this and the following species.

SPECIES STUDIED: *P. gracilis* Gr.

NOTES: This genus was described as follows, "Scale divided into two portions, each with small grooves radiating from its apex, antennæ 8-jointed." This description is so incomplete that it is impossible to determine if *P. gracilis* is really congeneric with the genotype. It would be impractical

to attempt a definite diagnosis of the genus based upon a species as uncertain as is *gracilis*.

However, if *gracilis* really belongs with *Parafairmairia*, this genus is a member of the *Exaeretopus* group. The genera will very probably require rearrangement when more forms are known.

Genus **Luzulaspis** Ckll.

TYPE: *Aspidiotus luzulæ* Dufour.

SPECIES STUDIED: *L. luzulæ* (DuFour), *L. australis* (Maskell).

ADULT FEMALE: Very long and slender, with the frontal area quite strongly produced; derm remaining membranous throughout and the body shriveling up to one end of the white, cottony ovisac; legs very long and slender, the tibia knobbed at the point of articulation with the tarsus; antennæ slender, 8-segmented; anal plates small, with cephalo-lateral and caudo-lateral margins approximately equal in length, the mesal margins rough and bearing setæ; marginal setæ small, acicular or trichiform; stigmatic depressions obsolete or very slight; stigmatic setæ 2 or absent; with long slender setæ between the antennæ and with or without median ventral groups on each abdominal segment; tubular ducts small, with very shallow cup, numerous on both dorsal and ventral sides and probably responsible for the sac that nearly or quite covers the body; multilocular pores on the ventral side in the anal region and in transverse rows; simple pores along the mid-line of the dorsum or widely distributed, nearly as large as the multilocular pores.

FIRST STAGE: Antennæ very long, 6-segmented; legs normal; margin with trichiform setæ; no body setæ except between bases of antennæ and in ventral abdominal region; anal plates not reticulate; quinquelocular pores in stigmatic depressions; anal ring with 6 setæ.

NOTES: *Luzulaspis* is very close to the three other genera of this group. The only distinctive character that I could find is in the form of the anal plates, which in *Luzulaspis* are nearly quadrate in shape, with the inner margins rough and bearing setæ. It is very doubtful that this is enough for the maintenance of the genus.

4. UNGROUPABLE FORMS.

Genus **Cardiococcus** Ckll.

TYPE: *Cardiococcus umbonatus* Ckll.

SPECIES EXAMINED: *C. fossilis* (Maskell) and *C.* (*Inglisia*) *castilloæ* (Gr.).

ADULT FEMALE: In life covered with a brittle, waxy scale; legs and antennæ either normal and well-developed or reduced; spiracles large and prominent; anal cleft very short and wide; anal plates small,

slender, apices pointed, with apical, discal, sub-apical and fringe setæ, the operculum surrounded by a sclerotic area; marginal setæ short, stout, spearhead-shaped; stigmatic depressions faintly indicated and with one short, stout, bluntly pointed seta which is considerably larger than the marginal setæ; tubular ducts present on the venter, small, with a deep cup; 8-shaped pores (Plate II, 1) present on the dorsum in a single row along the mid-line from the anal plates to the anterior portion of the head and interspersed with large, round tubercle-like pores; and also present in a row around the margin of the body; tubercle-like pores large, mingled with the 8-shaped pores along the dorsal mid-line; simple pores (Plate II, 2) both ventral and dorsal, occasionally two of them together forming an 8-shaped pore; quinquelocular pores in narrow bands in the stigmatic furrows and a few on the ventral side in the anal region.

NOTES: I have not seen *Cardiococcus umbonatus* Ckll., the genotype, but apparently *C. fossilis* (Maskell) is congeneric with this. *Inglisia castilloæ* (Gr.) seems certainly to be congeneric with *C. fossilis*. The rows of large 8-shaped pores and the stout spearhead-shaped marginal setæ are very characteristic of the genus.

Genus **Ceronema** Maskell.

TYPE: *Ceronema banksiæ* Maskell.
SPECIES EXAMINED: *C. dryandræ* Fuller.

NOTES: The members of this genus have well indented stigmatic depressions with several blunt setæ accompanied by a sclerotic plate and have many very large tubular ducts around the body margin. These tubular ducts somewhat resemble the submarginal tubercles of other *Coccidæ* but are differently constructed. There are often several other types of tubular ducts in addition to these. Morrison[4] has given a diagnosis of the genus to which I have nothing to add except the notes which I have previously given concerning these ducts and a figure of one of them (Plate I, 28).

Genus **Ceroplastes** Gray.

TYPE: *Ceroplastes janeirensis* Gray.
SPECIES EXAMINED: *C. albolineatus* var. *vulcanicus* Ckll., *ceriferus* (Anderson), *cirripediformis* Comstock, *cistudiformis* Townsend and Ckll., *dugesii* Towns., *floridensis* Comstock, *irregularis* Ckll., *rubens* Maskell, *rusci* (L.), *scutigera* Ckll., *sinensis* Del Guercio.

[4]Morrison, H. Proc. U. S. Nat. Mus. 60: 60, (1922).

ADULT FEMALE: (Fig. VI, 8) Body completely covered by a dense, amorphous waxy mass of varying shape, but often marked off into distinct plates; in some species there are 4 well-defined stigmatic bands of white wax originating at the stigmatic depressions and extending part way over the waxy covering; derm strongly sclerotic at maturity; antennæ usually slender, 6-8-segmented and legs well developed but sometimes both are reduced as in *C. rubens* (Fig. VI, 1, 4); anal plates borne on an elevated, sclerotic tubercle, the plates small and narrow with the cephalo-lateral margins forming the cephalic margin of the operculum, discal setæ present; stigmatic depressions well-marked, with many conical or bullet-shaped setæ; marginal setæ usually very small and inconspicuous, blunt or pointed and at the most never prominent except in *C. scutigera*, which has conical setæ of the same size as the stigmatic setæ all around the body; body setæ few, occurring between the antennæ and in the ventral anal region; pores and ducts of several types present; tubular ducts (Plate I, 4, 10, 11) variable in form, a few found in some species both dorsally and ventrally, scattered or grouped around the anal and cephalic regions; irregular pores (Fig. VI, 8, 9), which are large pores made up of 2, 3 or 4 loculi and thickly scattered over the dorsum in nearly all the species and occurring ventrally around the margin in several, these probably responsible for the secretion of the test; trilocular pores (Plate II, 27, 29) which in *sinensis* and *irregularis* are thickly scattered over the dorsum, replacing the irregular pores in these species; trilocular oval pores (Plate II, 28) which are small ventral pores found in several species, usually forming marginal bands; multilocular pores found in all species examined grouped around the anal plates and sometimes in transverse rows on the venter of the abdomen; quinquelocular pores in wide bands in the stigmatic furrows.

FIRST STAGE (Fig. VI, 11): With 6-segmented antennæ; legs normal; abdomen sometimes with a reticulated band around the margin; without distinct stigmatic setæ or sometimes with 3 small rounded or conical stigmatic setæ; margin with small, slender setæ; anal lobes sclerotic; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ. Species examined, *C. ceriferus* and *C. irregularis* and two unidentified species.

NOTES: *Ceroplastes* is a very distinctive genus. In the absence of material representing the type species I am relying upon the common interpretation of the genus.

Genus **Ceroplastodes** Ckll.

TYPE: *Lecanopsis dugesii* Signoret.

SPECIES EXAMINED: *C. acaciæ* Ckll., *cajani* (Maskell), *dugesii* (Sign.).

ADULT FEMALE: With a glassy sac or test which is free from the body of the insect; antennæ 7-8-segmented, long and slender or reduced; legs well-developed; anal cleft very short relative to the length of the body; anal plates small, peculiar in shape, the anterior margins rounded and bulging, the apices slender and pointed; ventrally the segmentation

of the body is shown by deep folds; stigmatic depressions obsolete, the stigmatic setæ not distinct from the marginal setæ or sometimes represented by a single long, curved seta, marginal setæ short, stout, spearhead-shaped, set close together; tubular ducts occurring both dorsally and ventrally in broad marginal bands and probably producing the test; multilocular pores numerous on the ventral side around the anal region and in rows on the abdomen; quinquelocular pores in narrow stigmatic bands; anal ring with 6-8 setæ.

FIRST STAGE: Antennæ 6-segmented; legs normal; margin with short, stout, spearhead-shaped setæ; stigmatic setæ not distinct from the marginal setæ; body with a few small setæ on the ventral side near the antennæ and in the anal region; anal plates sclerotic; anal ring with 6 setæ; stigmatic furrows with a few quinquelocular pores.

NOTES: The characters as given are quite distinctive of this genus. The species treated seem all to be congeneric.

Genus **Cissococcus** Ckll.

TYPE: *Cissococcus fulleri* Ckll. The only species now included in the genus.

MATERIAL STUDIED: Somewhat fragmentary material of *C. fulleri*.

NOTES: This is the only member of the family *Coccidæ* that is a gall maker, the female forming a gall on the twigs of the host. The legs and antennæ are very small. The anal plates are narrow, bluntly pointed at the apices, with the lateral margins forming a continuous curve and with the dorsal surface beset with numerous small, stout setæ.

Ferris[5] has dealt with this species from the same material that I have examined and I have nothing to add. The fragmentary condition of the material makes any very definite conclusions concerning anything more than the broad features impossible.

Genus **Cryptes** Ckll. and Parrott.

TYPE: *Lecanium baccatum* Maskell.

MATERIAL EXAMINED: Specimens of the genotype.

NOTES: The completely fused anal cleft of the adult female, the long, curved, blunt-tipped marginal and body setæ, the stout, very short, blunt stigmatic setæ of the first stage are sufficient to isolate this genus. Morrison[6] has figured and described the species and I am unable to add anything to his discussion.

[5]Ferris, G. F. Can. Ent. 50: 112–3, Fig. 19, (1919).

[6]Morrison, H. Proc. U. S. Nat. Mus. 60: 80–83, Fig. 27, (1922).

Genus **Cryptostigma** Ferris.

TYPE: *Cryptostigma ingæ* Ferris, which is a synonym of *Pseudophilippia inquilina* Newstead.

SPECIES EXAMINED: *C. inquilina* and an undescribed species from Mexico.

NOTES: This distinctive genus has the legs reduced to the merest vestiges and retaining only the claw; the antennæ very small; the stigmatic depressions pronounced and each depression bearing a heavily sclerotic dorsal pore plate. Ferris carefully defined the genus in the original description and I have to add only a description of the pores and ducts as found in the genotype and an undescribed Mexican species.

Tubular ducts are apparently lacking; simple pores of two sizes and with a heavy outer ring are scattered over the dorsum; large multilocular pores with 6-7 or occasionally 5 loculi are present on the venter around the anal region and in transverse rows on the abdomen; stigmatic pore plates (Plate II, 32) bearing many small multi-locular pores; tubercle-like pores present only in the unidentified species at hand, many in the mid-dorsal region of the body.

Cryptostigma ingæ is apparently identical with *Pseudophilippia inquilina* Newstead, but it has nothing to do with the genus *Pseudophilippia*. There is some question as to whether *Cryptostigma* is not synonymous with *Akermes*.

Genus **Ctenochiton** Maskell.

TYPE: *Ctenochiton viridis* Maskell.

SPECIES EXAMINED: *C. viridis* Maskell and *Lichtensia lycii* Ckll., which appears to belong to *Ctenochiton* rather than to *Lichtensia*.

ADULT FEMALE: Morrison[7] has redescribed this genus and I shall here note merely the more important features as taken from his description. Adult more or less convex, usually very slightly so, covered in life with glassy, whitish or transparent wax plates; antennae 6-8-segmented; legs normal; marginal setæ small, conical, set variably from very close together to some distance apart according to the species; stigmatic setæ single, large, strongly differentiated; dorsal setæ wanting or very small; ventral setæ few; derm with tiny tubular ducts and ventrally with two sizes of mutilocular pores; with or without other types; anal cleft short, the anal plates small; anal ring with 6 setæ.

FIRST STAGE: Antennæ 6-segmented; legs normal; stigmatic setæ occurring singly; marginal setæ small, slender; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ.

[7]Morrison, H. Proc. U. S. Nat. Mus. 60: 71–4; Fig. 41, (1922).

NOTES: After a study of *Lichtensia lycii* Ckll. I have come to the conclusion that this species is a *Ctenochiton*. It differs from the typical character of the genus by having a large, almost spherical ovisac which covers the posterior end of the abdomen and rises partially from the dorsum instead of having glassy wax plates, and, unlike *C. viridis*, it has fringe setæ beneath the anal plates, but I believe there is close enough agreement in other characters to place it in this genus. It is certainly not a *Lichtensia*.

Genus **Eriopeltis** Signoret.

TYPE: *Eriopeltis lichtensteinii* Sign.

SPECIES EXAMINED: *E. coloradensis* Ckll., *E. festucæ* (Fonsc.).

ADULT FEMALE: At maturity enclosed within a white, felted sac, which is free from the body and leaves only the cephalic portion of the insect uncovered; derm remaining membranous throughout; antennæ and legs much reduced, antennæ 6-8-segmented, the legs with all parts present; dorsum beset with many short, stout truncate setæ; marginal setæ very small, conical; stigmatic setæ not distinct from the marginal setæ; stigmatic depressions obsolete; tubular ducts numerous, small, short, occurring on both dorsum and venter and probably responsible for the formation of the sac; tubercle-like pores arranged in a row along the dorsal mid-line; quinequelocular pores in narrow stigmatic bands; anal ring with 6-8 setæ.

FIRST STAGE: Antennæ 6-segmented; margin with short setæ; anterior end of the body with 8-10 short, stout, conical setæ, remainder of the body without setæ except about the bases of the antennæ and in the ventral abdominal region; anal plates protruding beyond the end of the body, somewhat reticulated; anal ring with 6 setæ.

NOTES: The genus *Eriopeltis* is very sharply defined by the truncate dorsal setæ which give its members the appearance of some species of *Eriococcus*. There is no other genus like it except the otherwise very different *Mallococcus* and in this the dorsal setæ are sharply pointed.

Genus **Filippia** Targioni-Tozzetti.

TYPE: *Filippia oleæ* (Costa).

SPECIES EXAMINED: *F. oleæ* (Costa) and *Lichtensia viburni* (Licht.).

ADULT FEMALE: At maturity entirely covered by a white, fluffy ovisac which is a little longer than the insect itself; antennæ slender, well-developed; legs well-developed with a free tibio-tarsal articulation having a heavily sclerotic, tarsal articular process, tibia nearly twice as long as tarsus; anal cleft relatively short; anal plates broad, irregularly shaped, with the cephalo-lateral margins concave and the caudo-

lateral margins convex, the mesal margins rough; marginal setæ conical, pointed or chisel-shaped; stigmatic depressions slight and with 3 blunt setæ which are distinct from the marginal setæ, the middle one equal to or slightly longer than the other two; venter with several small setæ between the antennæ and with a number of fairly long setæ on the abdomen; tubular ducts (Plate I, 7) abundant on the dorsum and probably responsible for the production of the ovisac, medium sized, with a fairly deep, square-bottomed, thick-walled cup and a rather broad filament; multilocular pores on the ventral side in the anal region and in transverse bands on the abdomen; quinquelocular pores in narrow bands in the stigmatic furrows; anal ring with 6-setæ.

NOTES: After a careful study and comparison of *Filippia oleæ* and *Lichtensia viburni* I have come to the conclusion that these two species are congeneric. The essential characters of the two are the same. The disposition of the species of *Lichtensia* will be discussed under the latter generic heading.

Genus **Hemilecanium** Newstead.

TYPE: *Hemilecanium theobromæ* Newstead.

SPECIES EXAMINED: *H. imbricans* (Gr.), which has previously been referred to this genus.

NOTES: Specimens of the genotype are not available, nor have I had at hand the literature in which it is described. However, if *H. imbricans* (Gr.), which has been referred by other authors to this genus, be actually congeneric with *H. theobromæ* the genus is quite well marked.

Antennæ and legs long and slender, the former 9-segmented; legs without distinct tibio-tarsal articulation; tarsus with a rudimentary suture which gives it a 2-segmented appearance; anal cleft relatively short; derm about anal plates sclerotic; anal plates large, broad, lateral angles broadly rounded, apices sharply pointed; marginal setæ crowded closely together, long, spearhead-shaped; stigmatic setæ not distinct from marginal setæ, stigmatic depressions obsolete; body with a few small setæ, especially around the submarginal region, between the antennæ and in the perivulvar region; pores and ducts of several types: tubular ducts (Plate I, 3) long, narrow, scattered over the body on the ventral side and especially numerous around the body margin: cribriform plates (Plate II, 34) four on the dorsum, large, round made up of many thick-walled pores; submarginal tubercles (Plate II, 29) 30-40 on each side of the body; tubercle-like pores in a large dorsal group just cephalad of the anal plates; simple pores (Plate I, 25), very numerous on the dorsum; multilocular pores on the ventral side in the anal region and in transverse rows; quinquelocular pores in groups around each spiracle and in narrow bands in the stigmatic furrows.

Genus **Inglisia** Maskell.

TYPE: *Inglisia patella* Maskell.
SPECIES EXAMINED: *I. castilloæ* Gr. *chelonioides* Gr., *malvacearum* Ckll., *patella* Maskell.

NOTES: *Inglisia* is a peculiar genus which Morrison suggests stands alone. The body of the adult female is very irregular in shape with angular margins; a very short anal cleft; small, triangular anal plates; obsolete stigmatic depressions; marginal setæ of two types, tapering and slender alternating with stout and clavate; dorsal cribriform plates composed of many round pores loosely grouped together (Plate II, 33).

Morrison[8] has described and figured *I. patella* Maskell and has given a diagnosis of the genus. He states that 11 species in addition to the type have been referred to the genus and that no one of these is congeneric with the type. I have studied specimens of three species, *castilloæ*, *chelonioides* and *malvacearum*, which have been referred to this genus and agree that none of these belongs to it. I would place *I. castilloæ* (Gr.) in *Cardiococcus*. I have at hand a single specimen of what is probably *I. malvacearum* Ckll. but on the basis of this inadequate material I can only say that it does not belong in *Inglisia*, and the same is true of *I. chelonioides* Gr., which I have represented by a single imperfect specimen.

Genus **Lecanopsis** Targioni-Tozzetti.

TYPE: *Lecanopsis rhizophila* Targ.
SPECIES EXAMINED: *L. brevicornis* Newstead, *L. formicarum* Newstead.

ADULT FEMALE: At maturity with a loose, cottony sac, or talc-like secretion or a glassy test; antennæ very much reduced, 6-7-segmented; legs very much reduced, short and stout but with all parts present; anal cleft relatively short; anal plates small, lateral angles moderately rounded, apices bluntly pointed; marginal setæ very short, pointed; stigmatic depressions obsolete and stigmatic setæ not distinguishable from marginal setæ; body setæ few, both dorsally and ventrally, minute; spiracles very large, set close to the body margin, with a circular pore plate surrounding each; multilocular pores large, with 7 loculi, distributed along the sides of the body and extending partially on to the dorsum; stigmatic pore plates large, circular surrounding the opening of each spiracle and bearing small, multilocular pores; simple pores numerous, scattered over the dorsum.

[8]Morrison, H. Proc. U. S. Nat. Mus. 60: 60–63; Fig. 20, (1922).

NOTES: The original description of this genus, as given by Targioni-Tozzetti was as follows; "Margin wide, with a deep anal cleft, anal lobes obtuse, approximate; antennæ short, conical, of 6 joints; mentum narrow; legs short, stout, tibiæ truncate and anteriorly grooved; tarsi ovate, acute." Newstead extended the characters of the genus to include *L. formicarum* Newstead, a species with 8-segmented antennæ and well-developed legs. Cockerell later added another species, *L. lineolata*, with 8-segmented antennæ and Maskell described another, *L. filicum* concerning which I have no information. Leonardi added *L. myrmecophila*, a species with 7-segmented antennæ and well-developed legs.

The original description of the genus is inadequate and in the absence of specimens of the type species it is impossible to be certain that all these species belong to the same genus. *L. brevicornis*, with its very much reduced legs and antennæ, seems to lie closest to the genotype and I have ventured to base a characterization of the genus upon it.

L. formicarum differs from *L. brevicornis* in having the legs and antennæ well-developed, tubular ducts present both dorsally and ventrally, multilocular pores on the ventral side in the anal region and in transverse rows and not distributed along the sides of the body. I am inclined to believe that it should be removed from *Lecanopsis*, although I am unable to place it in any other genus.

Genus **Lichtensia** Signoret.

TYPE: *Lichtensia viburni* Signoret.
SPECIES EXAMINED: *L. viburni* Sign., *L. lycii* Ckll.

NOTES: As I have pointed out earlier, I regard this genus as a synonym of *Filippia*. *L. lycii* I consider to belong to *Ctenochiton*. There are nine other species that have been referred to *Lichtensia* and these I can not place generically. They must for the present accompany their genotype into *Filippia*.

Genus **Mallococcus** Maskell.

TYPE: *Mallococcus sinensis* Maskell.
SPECIES EXAMINED: The genotype.

NOTES: This is an isolated genus with numerous large, conical setæ which are set in pits on the dorsum; with fairly

long, sharp marginal setæ and a single long, slender seta opposite each spiracle; 8-shaped pores on the dorsum and anal plates lobe-like and bearing rather long, stout setæ. It has been figured and redescribed by Morrison.[9]

As I have pointed out this genus resembles some of the Eriococcid forms and may indicate a relationship of the Coccids to the Eriococcids. It is a genus that must be studied carefully in connection with any consideration of the relationships of these groups.

Genus **Paralecanium** Cockerell.

TYPE: *Lecanium frenchii* Maskell.
SPECIES EXAMINED: *P. luzonicum* Ckll., *peradeniyense* Gr., *planum* (Gr.).

NOTES: The members of this genus are readily recognizable by the curious marginal setæ, which are modified into flattened and broadly expanded flabellæ. The stigmatic depressions are rounded incisions in the body margin with 3-4 short, blunt, stigmatic setæ. Morrison[10] has redescribed the genus and I have only a description of the first stage to add.

FIRST STAGE: Antennæ 6-segmented, legs normal, stigmatic setæ 3, somewhat flattened; margin with a few very small setæ; body setæ between the antennæ and on the posterior portion of the venter; anal plates small, narrow, sclerotic; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ. Species examined; *P. planum* (Gr.), *peradeniyense* Gr.

Genus **Pseudopulvinaria** Atkinson.

TYPE: *Pseudopulvinaria sikkimensis* Atk. (*Lefroyia castanea* Gr.).
SPECIES EXAMINED: *P. sikkimensis* Atk., represented only by fully adult material.

ADULT FEMALE: Enclosed within a felted sac; antennæ moderately long, 7-segmented; legs comparatively small, the femur short and thick, the tibia long and slender; anal cleft very short; anal plates narrow and slender, bearing a number of stout, rather long, setæ; anal ring with 6 setæ; stigmatic depressions obsolete and stigmatic setæ not distinguishable from the marginal setæ; tubular ducts few, present on the venter; quinquelocular pores rather large, numerous on the dorsum and probably responsible for the secretion of the sac; simple pores in small numbers present on the dorsum.

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[9]Morrison, H. Proc. U. S. Nat. Mus. 60: 60, (1922).
[10]Morrison, H. Proc. U. S. Nat. Mus. 60: 78–80; Fig. 26, (1922).

NOTES: This is a peculiar genus that contains but a single species. Green has been inclined to place it near *Eriococcus* but it seems to me quite definitely Coccid. Only an examination of proper material representing various developmental stages will permit its definite placing. It is one of the forms that should especially be studied in connection with any discussion of the broader group relationships.

Genus **Physokermes** Targioni-Tozzetti.

TYPE: *Coccus piceæ* Schrank.

SPECIES EXAMINED: *P. insignicola* (Craw), *P. taxifoliæ* Coleman.

ADULT FEMALE: Body naked at maturity, almost spherical and with the derm heavily sclerotic; antennæ long and stout, 6-segmented; legs slightly to very much reduced, but with all parts present; anal cleft short; anal plates absent in the adult, being lost at the second molt; stigmatic depressions obsolete; no marginal or stigmatic setæ; body setæ in several transverse rows on the ventral side of the abdomen and between the antennæ; sometimes with a few setæ along the margin of the anal cleft; tubular ducts large, with deep angular cup, scattered on both sides of the body; tubercle-like pores (Plate I, 30) numerous, scattered over the dorsum; multilocular pores numerous on the venter about the anal region and in transverse rows, the stigmatic bands composed of smaller multilocular pores.

FIRST STAGE: Antennæ 6-segmented; legs normal; marginal setæ present, slender; stigmatic setæ not differentiated or represented by two short, slenderly conical setæ opposite each spiracle; long setæ around the bases of the antennæ, on the venter of the abdomen and sometimes in a double row extending along the mid-line of the dorsum; anal plates only slightly sclerotic, somewhat reticulated; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ. Species examined: *P. concolor* Coleman and *P. taxifoliæ* Coleman, *P. piceæ* Schr.

NOTES: This genus includes the only *Coccidæ* in which the anal plates are lacking at maturity. All the known species occur on conifers and the group is undoubtedly homogeneous.

Genus **Takahashia** Cockerell.

TYPE: *Pulvinaria japonica* Ckll.

SPECIES EXAMINED: *T. jaliscenscis* T. & W. Ckll., *T. japonica* Ckll.

ADULT FEMALE: At maturity forming, from the ventral side of the abdomen, a very long ovisac, which pushes the insect away from the host; antennæ somewhat reduced, short, stout, blunt, 7-segmented; legs reduced, without free tibio-tarsal articulation; anal plates longer than wide, cephalo-lateral margin longer than caudo-lateral margin, with broadly rounded lateral angles, apices rounded, mesal margins

rough, with discal, apical and fringe setæ which are all fairly long and stout; marginal setæ short, pointed, tending to appear spearhead-shaped; stigmatic depressions obsolete and stigmatic setæ not differentiated from the marginal setæ; a few very small setæ about the bases of the antennæ and on the venter; tubular ducts (Plate I, 16) numerous, with deep cup and broad filament, scattered over both dorsum and venter; multilocular pores large, numerous, scattered over dorsum and venter intermingled with the tubular ducts, both together perhaps producing the ovisac; quinquelocular pores confined to narrow bands in the stigmatic furrows.

First Stage: Antennæ 6-segmented; legs normal; margin with very fine setæ; stigmatic setæ 3, short, conical, equal in length; body setæ lacking except in the ventral abdominal region and about the bases of the antennæ; anal plates reticulate; anal ring with 6 setæ; quinquelocular pores in stigmatic furrows.

Notes: This genus was originally based merely upon habit, the fact that the ovisac lifts the adult female entirely from the twig upon which it rests being regarded as significant. An examination of the two species *japonica* and *jaliscensis* shows clearly that they are not congeneric, although I have been unable to place the latter in any genus with which I am familiar. This species has large, well-developed legs; large, quadrate anal plates; stigmatic depressions with 2 short, blunt stigmatic setæ; many 8-shaped pores scattered over the dorsum (Plate II, 3); tubercle-like dorsal pores; tubular ducts of a type different from those of *japonica* and confined to the venter.

Genus **Vinsonia** Signoret.

Type: *Coccus stellifera* Westwood.
Species Examined: The genotype.

Notes: Lack of proper material of this genus has prevented a study of the pores and ducts and I have nothing to add to the figures and description given by Green in the *Coccidæ of Ceylon*. The curious character of a distinct suture which separates the sclerotic cephalic apex of the body from the remainder is quite distinctive.

Key to the Genera Previously Treated.

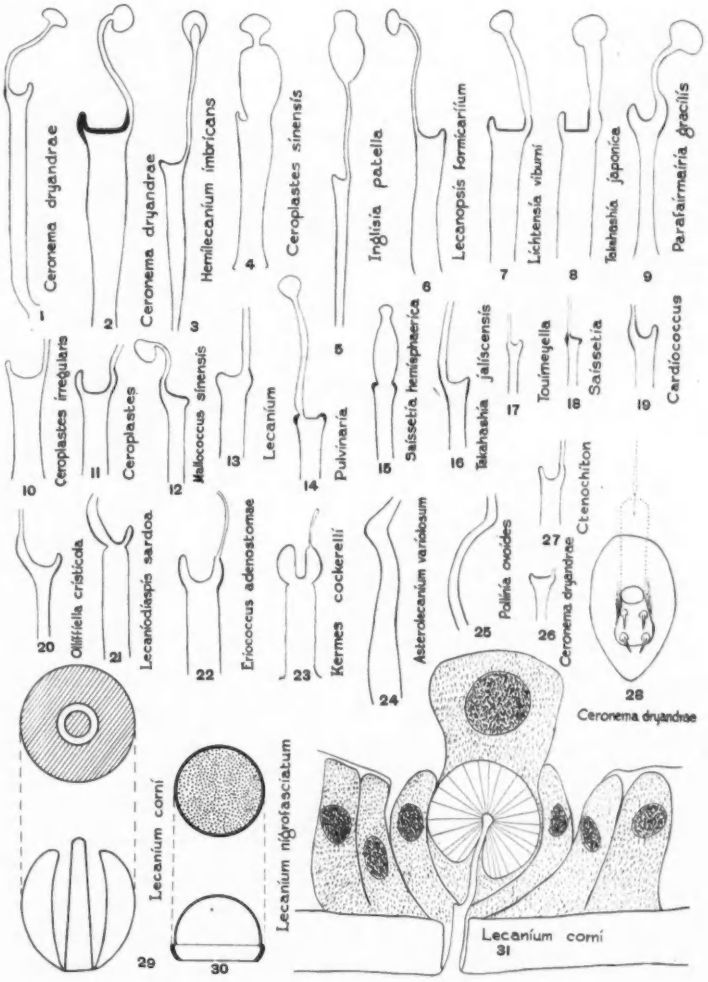
Previously existing keys to the genera of this family have been based wholly or in large part upon habit characteristics. An attempt is here made to present a key based wholly upon morphological characters. It considers only the adult female

and for its use properly prepared material of the early adult, taken before the derm has become sclerotic, is necessary. It must, unfortunately, be restricted to those genera which the author has been able to examine, this including only about half of the genera that have been named. It may serve, however, as an essay in aiding to reduce the study of these forms to a morphological basis.

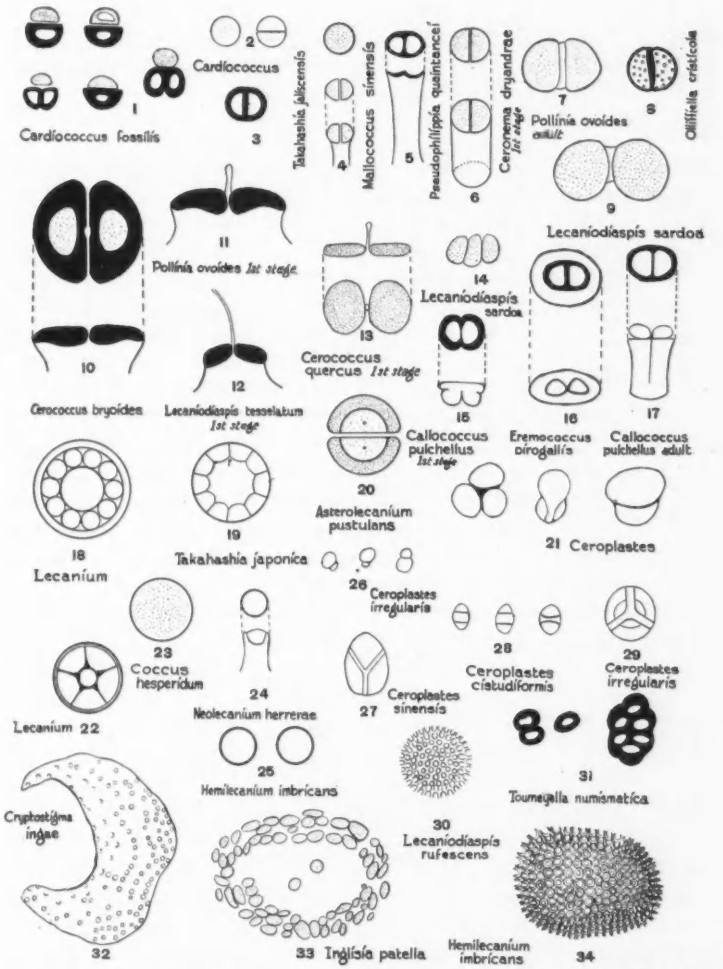
GENERIC KEY.

1. Adult female without anal plates.....*Physokermes*
   Adult female with anal plates..... 2
2. Dorsum beset with stout, truncate setæ.....*Eriopeltis*
   Dorsum not beset with such setæ..... 3
3. Dorsum beset with stout, conical, pointed setæ.....*Mallococcus*
   Dorsum not beset with such setæ..... 4
4. Well-marked stigmatic depressions beset with many tubercle-like setæ, anal plates borne upon a strongly sclerotic and more or less elevated process.....*Ceroplastes*
   Not so..... 5
5. Anal plates quite thickly beset with short, stout setæ; plates narrow with the lateral margins forming a smooth curve without angles.....*Cissococcus*
   Anal plates not of this form..... 6
6. Anal cleft completely closed.....*Cryptes*
   Anal cleft not completely closed..... 7
7. Body irregular-shaped with angular margins, marginal setæ of two kinds, tapering and slender, and stout and clavate, alternating; large, dorsal cribriform plates.....*Inglisia*
   Not so..... 8
8. Well-marked stigmatic depressions with several blunt setæ accompanied by a sclerotic plate, tubular ducts of several types, including many very large ones around the body-margins, which resemble submarginal tubercles.....*Ceronema*
   Not so..... 9
9. With a row of large 8-shaped pores along the mid-dorsal line and around the body-margin.....*Cardiococcus*
   Without such 8-shaped pores..... 10
10. Long spear-head-shaped marginal setæ, several large cribriform plates .....*Hemilecanium*
    Without such marginal setæ or cribriform plates..... 11
11. Cephalic apex of body separated from rest of body by a distinct suture, and with a waxy test produced into seven rays, giving it a seven-rayed star appearance.....*Vinsonia*
    Not so..... 12
12. Marginal setæ modified into broadly expanded and flattened flabellæ .....*Paralecanium*
    Marginal setæ not so modified..... 13
13. With many quinquelocular pores scattered over dorsum, narrow anal plates resembling somewhat Eriococcid anal lobes.....*Pseudopulvinaria*
    Not so..... 14
14. Many tubular ducts and multilocular pores scattered over the dorsum, antennæ and legs small, reduced; marginal setæ short, tending to be spear-head-shaped.....*Takahashia*
    Not so..... 15
15. Marginal setæ very short, broadly fimbriate, anal cleft extending nearly into center of body, anal plates long and very narrow, antennæ and legs very long and slender, body broadly pyriform.....*Protopulvinaria*
    Not so..... 16

16. With short, spear-head-shaped marginal setæ, stigmatic setæ not distinct, anal plates small, broadly rounded anteriorly with slender pointed apices; with very distinct segmentation on ventral side of thorax and abdomen.....*Ceroplastodes*
Not so..... 17
17. Legs greatly reduced, retaining only the claw; very deep stigmatic depressions with a large, strongly sclerotic pore-plate at the base of each depression.....*Cryptostigma*
Not so..... 18
18. Anal plates large, usually broad and quadrate-shaped with hypopigial and discal setæ, broad stigmatic bands of quinquelocular pores which usually extend down to and around the anal plates; marginal setæ lacking or small and inconspicuous.....*Toumeyella*
Not so..... 19
19. Many multilocular pores along the sides of body, legs and antennæ short, very much reduced, with a circular pore plate surrounding each spiracle, apparently without tubular ducts.....*Lecanopsis*
Not so..... 20
20. Body long and narrow with long antennæ, large legs with free tibio-tarsal articulation, with many multilocular pores on the venter around the anal plates and transverse rows upon the abdomen, with many tubular ducts both dorsally and ventrally, anal plates with apical setæ.....*Exaeretopus, Luzulaspis, Parafairmairia, Philephedra*
Not so..... 21
21. With small, conical marginal setæ and a single large differentiated stigmatic seta opposite each spiracle; anal plates broad, tapering posteriorly with one or two apical and several discal setæ....*Ctenochiton*
Not so..... 22
22. Marginal setæ of two types, chisel-shaped with a broad flattened apex, and conical, pointed; three blunt stigmatic setæ; anal plates broad, narrow anteriorly, broadly rounded posteriorly with the cephalo-lateral margins concave and the caudo-lateral margins convex.....*Filippia*
Not so..... 23
23. Marginal setæ variable in form; linear, pointed or slightly frayed at apices; fairly stout spike-like; small trichiform, but always much more slender than the stigmatic setæ. Three well differentiated stigmatic setæ and narrow stigmatic bands of quinquelocular pores..... 24
24. Without tubular ducts and with only a few multilocular pores on the venter around the anal plates.....*Coccus.* (*Eucalymnatus*)
With tubular ducts in broad ventral submarginal bands, many multilocular pores around the anal plates and in transverse rows upon the abdomen..... 25
25. With a large, discal setæ on each anal plate, marginal setæ fairly long, either pointed or moderately fimbriate at the apices.....*Saissetia*
Without a large discal setæ on each anal plate, marginal setæ not always as stated above..... 26
26. Legs without free tibio-tarsal articulation, with characteristic tubular ducts having short outer ducts, very round deep, thin-walled unsclerotized cups, and slender inner filaments.....*Lecanium*
Legs with free tibio-tarsal articulation, tubular ducts not of this type.... 27
27. Legs with free tibio-tarsal articulation, distinctive tubular ducts with short outer ducts, round shallow thick-walled cups which appear as sclerotized rings, and with long, slender inner filaments.....*Pulvinaria*



Tubular ducts of: 1, 2, *Ceronema dryandrae;* 3, *Hemilecanium imbricans;* 4, *Ceroplastes sinensis;* 5, *Inglisia patella;* 6, *Lecanopsis formicariium;* 7, *Lichtensia viburni;* 8, *Takahashia japonica;* 9, *Parafairmairia gracilis;* 10, *Ceroplastes irregularis;* 11, *Ceroplastes* sp.; 12, *Mallococcus sinensis;* 13, *Lecanium* sp.; 14, *Pulvinaria* sp.; 15, *Saissetia hemisphaerica;* 16, "*Takahashia*" *jaliscensis;* 17, *Toumeyella* sp.; 18, *Saissetia hemisphaerica;* 19, *Cardiococcus fossilis;* 20, *Olliffiella cristicola;* 21, *Lecaniodiaspis sardoa;* 22, *Eriococcus adenostomae;* 23, *Kermes cockerelli;* 24, *Asterolecanium variolosum;* 25, *Pollinia ovoides;* 26, *Ceronema dryandrae;* 27, *Ctenochiton viridis;* 28, *Ceronema dryandrae;* 29, submarginal tubercle of *Lecanium corni;* 30, tubercle-like pore of *Lecanium nigrofasciatum;* 31, section through gland with tubular duct in *Lecanium corni.*



8-shaped pores of: 1, 2, *Cardiococcus fossilis;* 3, *Takahashia jaliscensis;* 4, *Mallococcus sinensis;* 5, *Pseudophilippia quaintancei;* 6, *Ceronema dryandrae*, first stage; 7, *Pollinia ovoides*, adult; 8, *Olliffiella cristicola;* 9, *Lecaniodiaspis sardoa;* 10, *Cerococcus bryoides;* 11, *Pollinia ovoides*, first stage; 12, *Lecaniodiaspis tesselatum* first stage; 13, *Cerococcus quercus*, first stage; 15, *Callococcus pulchellus*, first stage; 16, *Eremococcus pirogallis;* 17, *Callococcus pulchellus*, adult; 20, *Asterolecanium pustulans.* Trilocular pores of; 14, *Lecaniodiaspis sardoa;* 27, *Ceroplastes sinensis;* 28, *Ceroplastes cistudiformis;* 29, *Ceroplastes irregularsis.* Multilocular pores of; 18, *Lecanium;* 19, *Takahashia japonica.* Irregular pores; 21, 26 of *Ceroplastes.* Simple pores of; 23, *Coccus hesperidum;* 25, *Hemilecanium imbricans.* Cribriform plates of; 30, *Lecaniodiaspis rufescens;* 31, *Toumeyella numismatica;* 32, *Cryptostigma ingae;* 33, *Inglisia patella;* 34, *Hemilecanium imbricans.*

NOTES ON METHODS OF REARING SARCOPHAGINÆ (DIPTERA), AND THE BIOLOGY OF SARCOPHAGA LATISTERNA PARK.*

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The literature of North American economic and medical entomology contains hundreds of references to the Sarcophaginæ, one of the subfamilies of the Sarcophagidæ. An investigation of these, in the cases where they deal with the immature stages, and in which the adult has not been reared, reveals that each is usually recorded as "Sarcophaga sp." There are but few cases, although the economic importance of the group is universally recognized, where notes on the larva have been preserved when the adult was reared. The writer has several times encountered larvæ of this subfamily while rearing parasites of Scarabaeidæ, but has been unable to identify the species, except in those cases in which the reared *Sarcophaga* was a male. As a result of this difficulty, the present study was undertaken to secure an understanding of the habits and of the distinctive larval characters of the Sarcophaginæ or "flesh-flies." In this paper a few notes on the methods used in rearing Sarcophaginæ and on the biology of *Sarcophaga latisterna* will be given. The latter is the only species, among those of this subfamily which were reared by the writer, of which the larva has not been recorded and described either by Mr. C. T. Greene[1] or by Prof. F. M. Root.[2]

INSECTARY METHODS.

Adult female *Sarcophaga*, which were captured in the field, were kept separately in cages for from 4 to 5 days with an ample supply of ten percent honey solution for food. During

*Contribution No. 46 of the Japanese Beetle Laboratory, United States Department of Agriculture, Moorestown, New Jersey.

[1]Greene, C. T. The puparia and larvæ of sarcophagid flies. Proceedings of the U. S. National Museum. Vol. 66, Art. 29, pp. 1–26, pls. 9. 1925.

[2]Root, F. M. Notes on larval characters in the genus Sarcophaga. Jour. of Parasitology 9: 227–229, pl. 1. 1923.

this period, attempts were made to induce the flies to place larvæ upon freshly killed insects. In many cases, the flies, although gravid, would not larviposit in the cages. The maggots were then dissected from the gravid female and were placed upon freshly killed *Popillia japonica* grubs. If the species was accustomed to feeding on insect tissue in the larval stage, the maggots fed rapidly and developed normally.

In this work, special cage methods were used to prevent outside contamination by larvæ of any of the common muscoid flies. Adults or larvæ of the sarcophagids were placed in tight, glass topped cages of 6 by 8 by 10 inches. All of these small cages were placed in a 40-mesh wire-cloth covered cage 7 feet long, 4 feet wide and 4 feet high. This made it nearly impossible for a female muscoid fly to introduce eggs or maggots into the inner cage. The larval food which was placed in the center of the inner cage, was kept in a tin can with sides almost 2 inches high.

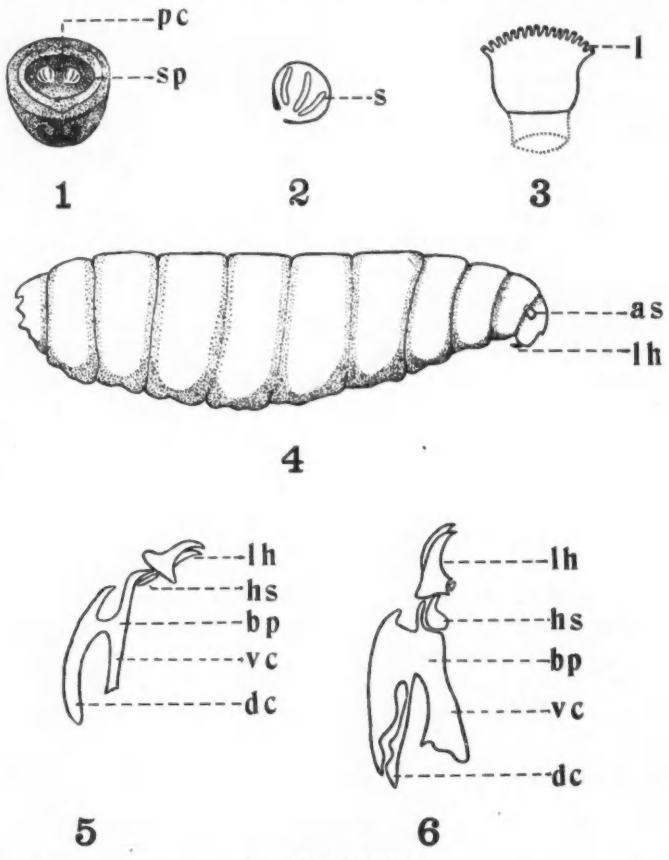
In every case, the progeny of a single female fly was kept in a single cage within the large cage. Specimens of first-stage and fully developed maggots were preserved for study. A large series of adults was reared from each female sarcophagid, all of which were carefully examined to be sure that only one species was present, and in no case was any contamination by muscoids discovered.

NOTES ON SARCOPHAGA LATISTERNA.

A large number of *Sarcophaga latisterna* were observed flying on October 1, 1926, around the larvæ of a species of *Anisota* (Lepidoptera) at Taunton Lakes in southern New Jersey. Nearly all of the *Anisota* larvæ at that time had ceased to feed on the oak leaves, and many had wandered to the edge of the road, where they had been killed by passing vehicles. Both the live and the dead *Anisota* larvæ were very attractive to those sarcophagid flies. The writer did not rear *Sarcophaga latisterna* as a parasite of *Anisota*. The closely related *Sarcophaga cimbicis*, which was numerous at the time *S. latisterna* was observed about the dead *Anisota* larvæ, was reared from adults of the rhinocerus beetle *Xyloryctes satyrus* at Jericho, Long Island, on September 2, 1927.

An adult female of *Sarcophaga latisterna* was captured from among those flying around the *Anisota* larvæ, and was kept

four days in a cage with plenty of food and freshly killed *Popillia japonica* grubs. As it did not larviposit upon the dead insects in the cage, numerous very active larvæ were



Sarcophaga latisterna.

Fig. 1. *Posterior end of third-instar larva.* pc, posterior cavity; sp, spiracular plate.
Fig. 2. *Spiracular plate of third-instar larva.* s, spiracular slit.
Fig. 3. *Anterior spiracle of third-instar larva.* 1, tubules.
Fig. 4. *Third-instar larva.* as, anterior spiracles; lh, lateral hooks.
Fig. 5. *Buccopharyngeal apparatus of first-instar larva.* bp, basal piece; dc, dorsal cornu; hs, hypostomal sclerite; lh, lateral hooks; vc, ventral cornu.
Fig. 6. *Buccopharyngeal apparatus of third-instar larva.* Explanation of letters the same as for Fig. 5.

removed from it by dissection and were placed on freshly killed *P. japonica* grubs. The young sarcophagid larvæ developed very rapidly, and, after feeding for a period of 4 or 5 days, began to wander away from their food. On the following day they pupated at the bottom of the soil in the cage, and remained in this stage for one month. The shortness of their larval period may be compared with that of *Sarcophaga bullata*, in which it took 11 days for the larvæ to develop, from the time they began to feed until they pupated. It is apparent that *Sarcophaga latisterna* is able to complete its development on a very transitory food supply.

DESCRIPTION OF IMMATURE STAGES.

First-Instar Larva.—The larva is white, opaque, and without strongly pigmented contents. There are eleven segments, in addition to the head. The minute, light-colored chitinous spines on the cuticula are confined to the segmental lines. The spiny areas along the segmental lines are broader on the ventral side, and the ventral spines on body segments 2 to 6, inclusive, are dark colored. The articulated buccopharyngeal apparatus (Fig. 5) is equipped with two mandibular hooks. The basal piece of the pharyngeal skeleton consists of two lateral chitinized plates which are connected dorsoanteriorly. The mouth opening is located ventrally beneath the two great hooks. The larva is metapneustic, and the posterior spiracles are situated on two plates in a deep cavity just above the anal opening.

Third-Instar Larva.—(Fig. 4). The larva, which is yellowish white, tapers to a point at the anterior end, is somewhat truncate at the posterior end, and slightly curved ventrally. Beginning with the second instar the larva is amphipneustic. There are eleven segments which are about equal in length, in addition to the head. The minute, chitinous spines on the cuticula are confined to the segmental lines. The posterior cavity (Fig. 1) is elliptical, nearly twice as long as wide, about as deep as the width at the surface, and lacks any well developed tubercles on its edges. The posterior spiracular plates (Fig. 2), which are at the bottom of this cavity, are separated by approximately one-third their width. Each plate has three slits converging at their base. The anal tubercles are very feebly developed. The articulated buccopharyngeal skeleton (Fig. 6) is equipped anteriorly with a pair of strong lateral hooks, and has a smaller, median hypostomal sclerite between the hooks and the basal piece. The basal piece of the buccopharyngeal skeleton consists of two lateral chitinized plates which are connected dorsoanteriorly by a curved, narrow band. Each lateral plate is incised deeply posteriorly, so as to form ventral and dorsal *cornua* in all stages of the larva. In the third-instar larva, the dorsal *cornu* is deeply incised posteriorly. There are two minute papillæ on each side of the head, which are just barely elevated. The anterior

spiracles (Fig. 3) each have 16-18 small tubules. In Mr. Green's key to *Sarcophaga* larvæ[3] this species falls under couplet 4, and can be separated from *Sarcophaga bullata* and *Sarcophaga securifera* by the absence of well developed anal and posterior-cavity tubercles, as *Sarcophaga latisterna* has only a slight trace of these tubercles.

Length, 12-13 mm.; diameter, 3 mm.

PUPARIUM.—The medium to large sized, dull-reddish puparium of *Sarcophaga latisterna* was so well described by Mr. Greene[4] that it will be unnecessary to give details here. As the anterior spiracles were missing in Mr. Green's material, this information may be added to his description; anterior spiracles arcuate, about three-fourths as high as wide; each spiracle with 16-22 yellow tubules, and the basal portion of the spiracle dark reddish.

Length, 6.7-9.5 mm.: width, 3.5-4 mm.

There is very little information in the literature about the habits of *Sarcophaga latisterna*. Dr. J. M. Aldrich states[5] that he had a specimen which had been reared from *Pontia rapæ* by E. D. Brown. The adult fly emerged November 18, 1907, at College Park, Maryland. Phillips and King report[6] that *Sarcophaga latisterna* was reared from *Heliothis obsoleta*.

CONCLUSION.

It may be concluded that the habits of *Sarcophaga latisterna* as well as those of some of its close relatives are plastic. Although they often develop as scavengers, they may be true parasites in some cases. It may be that what we observe is the parastic habit in the process of development.

The larvæ of the Sarcophaginæ show good specific characters, as far as they have been studied, and it is to be hoped that the work will be extended to include more species.

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[3]Op. cit., p. 6.

[4]Op. cit., p. 18.

[5]Aldrich, J. M. Sarcophaga and Allies in North America, p. 77. Thomas Say Foundation Fund, Vol. 1, pp. 302, pls. 16. 1916.

[6]Phillips, W. J., and King, K. M. The corn ear worm: its ravages on field and suggestions for control. p. 12. U. S. Dept., Agri., Farmers Bulletin 1310, pp. 17, Fig. 18. 1923.

THE TRIBE PEMPHIGINI (APHIDIDÆ) IN UTAH.*

ASA C. MAXSON† AND GEORGE F. KNOWLTON.

Thecabius populi-monilis (Riley).

This aphid forms characteristic rows of bead-like cells, particularly on the upper sides of the leaves of narrow-leaved cottonwood, *Populus angustifolia*, and to a less extent on some of the wider-leaved species of poplars. The stem mother produces a gall similar to that formed by her young. These galls occur singly, usually between the midrib and the margin of the leaf. The first bead-like rows of galls are produced by the young of the fundatrix. Only a single individual is found in each cell.

According to Gillette, most of the second generation lice become winged and leave the galls, thus serving to scatter the species from tree to tree. A portion, especially of the later lice that are born, remain apterous, remain in the galls, and give rise to the third generation. These young, like the young from the stem mother, also migrate to the new leaves to continue the production of galls each of which harbors but one louse at first, but a portion of the young of this brood remain with the mother in the gall and become winged sexupara, of which 10 or 12 may be found in a single gall with the parent. Emergence of these sexupara begins about the first week of August and continues until the last of September; soon after emergence the sexupara give birth to the sexual forms.

On the narrow-leaved cottonwood, the galls are most commonly in rows, on one or both sides, and rather paralleling the midrib. On *P. balsamifera*, the rows may follow the margin, parallel the midvein, or run at different angles on different parts of the leaf. Sometimes three or four rows of galls will occur on the broad part of the leaf.

The stem mother usually has 5-jointed antennæ and is wingless. The winged individuals of the second generation

*Contribution from the Department of Entomology, Utah Agricultural Experiment Station. Approved for publication by Director, July 18, 1928.

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emerge from the galls within a period of a few weeks. The mouth of the gall opens slowly, finally permitting the winged female to emerge. Predators frequently enter the opening galls and kill the pupal nymphs. Several species of syrphid larvæ and a small hemipterous insect were the forms most commonly observed in Utah.

Wingless females were numerous in the galls at St. George, on July 9, 1925. These had broad abdomens and contained many embryos. The antennæ of these females are 5- or 6-segmented; however, the last division of the antennal III is usually incomplete. In most cases at least one antenna is strictly 5-segmented, with no indication of a sixth.

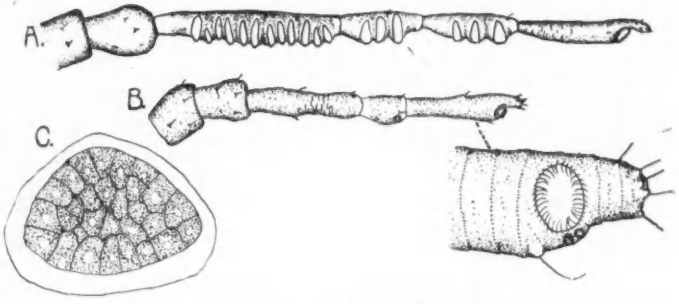

Fig. 1. *Thecabius populi-monilis* (Riley).
A, antenna of spring migrant; B, antenna of stem mother; C, wax pore plate from abdomen of stem mother.

This species has been collected in Utah from Blacksmith Fork Canyon, Cedar City, Eden, Farmington, Hyde Park, Murray, Logan, St. George, Salt Lake City, Santa Clara, and Smithfield.

Thecabius populi-conduplifolius (Cowen).

This aphid folds the leaves of balsam poplar, *Populus balsamifera* and *P. deltoides*, producing a pseudogall along the midvein or parallel to it. The stem mothers may be found in galls near the margin of the leaf. The young of the stem mother do not remain in the gall with her, but migrate to the new leaves at the tips of the branches. All of the second generation become winged. They migrate to *Ranunculus* sp. where the third and several subsequent generations of apterous

viviparous females are produced. These summer colonies give a cottony appearance to the base of the *Ranunculus* leaves and stems. The fall migrants (sexupara) appear during late summer and fall and migrate back to the cottonwoods where the sexual forms are produced.

Galls of the second generation are always on terminal leaves. However, late in the season, after the stem mother ceases producing, new terminal leaves are produced which do not become infested.

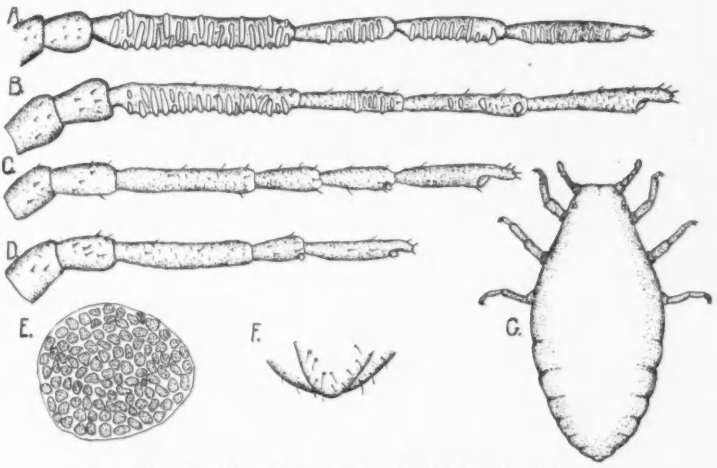

Fig. 2. *Thecabius populi-conduplifolius* (Cowen).
A, antenna of spring migrant; B, antenna of fall migrant; C, antenna of apterous form from *Ranunculus* sp.; D, antenna of stem mother; E, wax pore plate from abdomen of stem mother; F, cauda and anal plate of spring migrant; G, oviparous female.

At Fruita, and along the stream below Capital Bridge, nearly all of the leaves on the young poplars were folded on June 27, 1926. By this time most of the aphids had migrated. Many of the aphids had been parasitized, but a few living specimens were obtained. These aphids were quite numerous in the galls at Randlett on July 14, 1927, and less so at the same time in the few collections made at Fort Duchesne and Vernal. Ordinarily, quite a number of aphids occur in each gall. When they were examined at St. George on July 9, 1925, only a few specimens remained in galls. Winged females were becoming abundant at Plain City, by June 15, 1928.

Pemphigus populi-caulis Fitch.

Pemphigus populi-caulis and *Pemphigus populi-globuli* were described by Dr. Asa Fitch in the "Report of the Noxious and Other Insects of the State of New York," 1859.

Fitch's descriptions of the insects are too meager to make a separation of the species certain without the galls.

The gall produced by the aphis Fitch described as *P. p.-caulis* is described as a "bullet-like gall" on the middle of a leaf stalk from a Lombardy poplar. This gall was found on the 27th of June, three years before the description of *P. p.-caulis* was published.

Discussing the gall further, Fitch says: "When the leaves fell from this tree in autumn, a few were found among them, more faded than the others and having these same excrescences, but placed at the base of the leaf instead of on the middle of its stem . . . . . ."

Farther on in his discussion, Fitch states: "Galls analagous to those here described grow upon the leaf stalks of the Lombardy and Black poplar in Europe, from attacks of the *Pemphigus bursarius* of Linnaeus."

After comparing it with specimens of that species and its galls, Fitch considered his aphid different from *P. bursarius*, because of " . . . . the fly being paler in its color, and its gall spirally coiled somewhat like the shell of a snail."

It is very evident from Fitch's discussion that he had in mind, when he described *P. p.-caulis*, a gall located on the petiole of the leaf at some distance from the leafblade, and one produced by a twisting of the petiole into a spiral.

It is quite probable that the petiole gall described by Fitch is not typical of *P. p.-caulis*, but that those at the the base of leaf which he mentions as being taken in the fall are the typically located galls.

The aphid herein figured and described as *Pemphigus populi-caulis* is from galls located at the base of the leaf and produced by a twisting or spiralling of the petiole. The species described as *P. p.-globuli*, is considered to be the *globuli* of Fitch because of the likeness of its gall to the one described by Fitch in his discussion of that species.

Since the original descriptions of *P. p.-caulis* and *P. p.-globuli* were published these species have received much attention, if we may judge from the frequent references to both. However,

in spite of this, several aphidologists appear to have failed to distinguish between them.

P. p.-caulis and *P. p.-globuli* are very similar structurally and their galls are, in a general way, much alike, although quite different when studied in detail. This general similarity of both the aphids and their galls appears to have caused considerable confusion in the literature. This was probably increased by a lack of detail in the earlier descriptions.

In studying the two species under discussion, the senior author has collected material from several states and in many localities in some of these states. When collections of both species have been made in the same locality, they rarely have been found on the same host species. In Colorado and Utah *P. p.-caulis* was taken on *Populus deltoides* and *P. p.-globuli* on *Populus angustifolia* and *Populus balsamifera*. In California *P. p.-caulis* was taken on *Populus Fremontii* and *P. p.-globuli* on *Populus trichocarpa*. *P. p.-caulis* was taken on *Populus deltoides* at St. Cloud, Minnesota, and both species on *Populus balsamifera* at Oak Park, Minnesota. East of the Rocky Mountains in Montana *P. p.-caulis* was taken on *Populus deltoides* and *P. p.-globuli* on *Populus angustifolia*. *P. p.-caulis* was taken on *Populus balsamifera* in the Bitter Root Valley of Western Montana and *P. p.-globuli* on the same species of Populus near the Flat Head Lake. The junior author reports both species on *Populus balsamifera*. These observations appear to indicate that *Populus balsamifera* is the only common host of *P. p.-caulis* and *P. p.-globuli* east of the Rocky Mountains. *Populus trichocarpa* may serve as a host for both in the range of this tree.

These collections have been carefully separated according to the type of gall and a large series of the aphids from each gall type critically studied. These studies have brought to light certain structural differences by which *P. p.-caulis* and *P. p.-globuli* alate forms from the galls may be separated. These differences are constant in relative magnitude but not in actual magnitude.

Both species under discussion are quite variable in size and in some other characters. This necessitates studying several individuals and comparing the means of characters in order successfully to separate them. When a sufficient number of individuals to make a representative population is studied, separation becomes easy and certain.

The principal characters used by the senior author are: The number of sensoria on the antennal joints, the relative numbers of joints IV with less than 4 sensoria, and the antennal coefficient which is determined by the following formula:

$$\frac{\text{Length of III + IV + V + VI including spur}}{\text{Length of hind tibia}}$$

and the coefficient of antennal joint VI. This is determined by the formula,

$$\frac{\text{Length of joint VI + spur}}{\text{Length of joint III}}$$

Pem. populi-caulis and *Pem populi-globuli* are compared below by means of these characters.

	P. p.-caulis			*P. p.-globuli*		
Location	Antennal Coeff.	Coeff. of VI	Percentage of IV's with less than 4 Sensoria	Antennal Coeff.	Coeff. of VI	Percentage of IV's with less than 4 Sensoria
Montana.....	0.8657	0.7676	44	0.8171	0.8865	87
Minnesota.....	0.9395	0.8283	52	0.7942	0.9550	83
Colorado.....	0.8718	0.8079	44	0.8382	0.9535	85
Utah.....	0.9719	0.8629	0	0.7759	0.9125	83
California.....	0.9894	0.8263	9.8	0.7836	0.8331	85

In *Pem. populi-caulis* the antennal coefficient exceeds the coefficient of VI and the percentage of joints IV with less than 4 sensoria is always less than 60. A collection from Louisiana had 55 per cent. This is the largest percentage among collections from 9 states.

Pem. populi-globuli has the coefficient of VI greater than the antennal coefficient, the coefficient of VI greater than that of *Pem. populi-caulis*, and the percentage of joints IV with less than 4 sensoria always more than 60. Material from Idaho had 70 per cent. This is the lowest among collections from 6 states.

Thomas, in the "Third Annual Report on Noxious and Beneficial Insects of Illinois," 1879, pictures a typical *Pem. populi-globuli* gall for the gall of *Pem. populi-caulis*. Dr. O. W. Oestlund described *Pem. populi-caulis* in his synopsis of the Aphididæ of Minnesota. His description is not sufficiently

detailed to determine which of the two species under discussion he really had. The host is given as *Populus monilifera*. The length of antennal joint III and VI with the unguis, are given as the same. This makes the coefficient of VI, 1.0000. Collections of *Pem. populi-globuli* and *P. p.-venæ* have a coefficient of VI equal to or greater than 1.0000, but *P. p.-callis* never has a mean coefficient of this magnitude. Material collected from *Populus deltoides* at St. Cloud, Minnesota, in 1914 has an antennal coefficient of 1.0103 and a coefficient of VI of 0.6564. These were from typical *P. populi-caulis* galls. Another collection from *Populus balsamifera* made at Oak Park, Minnesota, had an antennal coefficient and of 0.9395 and a coefficient of VI of 0.8283. It appears that there may be some doubt of the identity of Oestlund's 1887 material.

E. O. Essig, in Pomona College Journal of Entomology, 1912 describes and illustrates *Pem. populi-caulis* and several galls. These galls are of 3 quite distinct types. One is typical of *Pem. p.-caulis*. Several are typical *Pem. p.-globuli* galls and one is typical of what the senior author is calling *Pem. p.-venæ*. The senior author has collected all three types of galls on *Populus trichocarpa* in California. The aphids from the typical *Pem. p.-globuli* and *Pem. p.-caulis* were the ones used in the studies already referred to. The ones from the other type of gall do not fit with either *Pem. p.-caulis* or *Pem. p.-globuli*. Several collections of these galls have been made in Minnesota. The aphids from Minnesota differ from the species being discussed in the same way as those from California. This species is described later as *Pem. p.-venæ*. The descriptions of Essig are not sufficiently detailed to enable one to determine his species with certainty. However, his figures of the antenna, of the alate viviporous female and the stem mother are typical of *Pem. p.-caulis*.

The California material in the senior author's collection is compared with that of Essig's below.

Most Frequent Number of Sensoria	*P. populi-caulis*	*P. populi-globuli*	Essig Material
III	10–11	9–10	10–14
IV	4–5	2–3	3
V	4–5	3–4	3–5
VI	6–7	4–5	7–8

It seems quite probable that Essig failed to separate the 3 species in his material. This appears to have given his species slightly different proportions and number of sensoria on the several antennal joints than typical California *Pem. p.-caulis.*

Dr. Edith M. Patch* described *Pem. populi-caulis* from *Populus balsamifera* and pictures 1 typical *Pem. populi-globuli* gall and 2 not typical of this species or of *Pem. populi-caulis.* The latter are similar to galls taken by the senior author at Oak Park, Minnesota, produced by what he calls *Pem. populi-venæ.*

Dr. Patch pictures the antenna. This shows joint VI to be the same length as III. This is not typical of *Pem. populi-caulis.* The senior author has examined material from the collection used in Dr. Patch's work and from the typical *Pem populi-globuli* gall figured in Bulletin 213. This material is typical *Pem. populi-globuli* having an antennal coefficient of 0.9719, coefficient of VI, 1.0000 and 83.3 per cent of joints IV with less than 4 sensoria.

There seems to be evidence that Dr. Patch also was working with *Pem. populi-globuli* and the form being called *Pem. populi-venæ* and not *Pem. populi-caulis.*

Pemphigus populi-caulis.

DESCRIPTION.

Fundatrix:

Color.—Greenish to whitish green.

Wax pore plates; normal for the genus; head, none; prothorax, 4; meso- and meta-thorax and abdominal segments I to VI each with 6; segment VII, 2. Marginal plate usually the largest.

Dimensions.—Total length, about 3.39 mm.: width, about 2.08 mm. Relative length of antennal joints; I, 4.5; II, 4.5; III, 10; IV, 6. Joint III club-shaped, the distal portion about half greater in diameter than joint IV. Permanent sensoria on III and at base of poorly defined spur on IV fringed with cilia. There is a somewhat oval, clear area at a point about two-thirds the way from the base of III. Joints III and IV weakly imbricated. Imbrications bear small tubercles which terminate in a small spine. A few rather large more or less curved hairs on tubercles on all joints.

Relative length of fore femora, 23; tibia, 18; tarsi, 8.5; middle femora, 24.5; tibia, 20.5; tarsi, 8.5; hind femora, 32; tibia, 30; tarsi, 10.

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*Maine Expt. Sta. Bul. 213, 1913.

Fundatriginia (Summer migrant).

Color.—After exposure to the light the living insect has a bluish tinge due to a covering of fine whitish powder. The head and thorax are dark, almost black; the abdomen is a yellowish or yellowish-green; the antennæ and legs are dusky brown; the posterior margin of the stigma is dusky; the wing veins are slightly dusky to brownish.

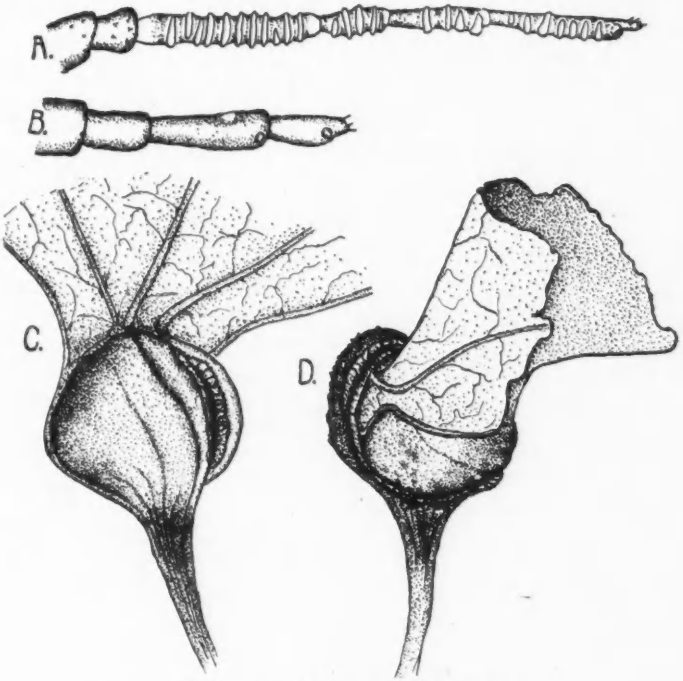


Fig. 3. *Pemphigus populi-caulis* Fitch.
A, antenna of spring migrant; B, antenna of stem mother; C and D, galls on poplar.

The venation is normal for the genus. First and second discoidals of the forewing normally with their bases distinctly but not widely separated, frequently united. Basal one-fourth to one-third discoidal obsolete. Stigmal vein curved, well developed. Diagonals of hind wing normally arising from nearly the same point. Rarely with bases widely separated.

Dimensions.—Total length about 1.9 mm. Abdomen about 0.69 mm. wide. Forewing about 2.60 mm. long, width about 0.95 mm. Stigma about 0.60 mm. long and 0.17 mm. wide at point where stigmal

vein is attached. Hind wing about 1.80 mm. long and 0.50 mm. wide at widest point.

Antennæ 6-jointed. Sixth joint with a short unguis. Joints III, IV, V, and VI with transverse secondary sensoria annular. Sensoria rarely encircling the joints. Permanent sensoria at distal extremity of V and at base of unguis on VI more or less oval, surrounded by a fringe of cilia. Joint III with 9-13 sensoria, most frequently 10-11; IV with 3-5, most frequently 4; V with 3-5, most frequently 4; VI with 4-7, most frequently 7. Antennal coefficient larger than coefficient of joint VI; percentage of joints IV with less than 4 sensoria less than 60*.

Relative length of antennal joints.—I, 3.5; II, 3.5; III, 13.0; IV, 6.0; V, 6.5; VI, 10.5 The length of the antennal joints are quite variable even in the case of the two antennæ of a single individual.

Relative length of fore femora 24, tibia 28, tarsus 8; middle femora 20, tibia 28, tarsus 8.5; hind femora 26, tibia 38.5, tarsus 9.5. In all collections there are apt to be a few quitè small individuals. The measurements given are those of a normal sized specimen.

The Gall.—The gall is semi-globular. Large ones attain a diameter of ½ inch or more. Normally located galls are at the base of the leaf where the blade and petiole unite. The gall is composed of the thickened and twisted petiole and a very small portion of the base of the leaf blade which frequently extends a short distance down onto the gall. The greater part of the gall extends below the plane of the leaf blade. Viewed from above the mouth is normally not visible and the midrib and the first diagonal veins on either side are seen to merge into the body of the gall.

When viewed from below the midrib is seen to bend abruptly and to merge with a ridge formed by the edge of the petiole which follows the curve of the gall and forms a part of one lip of the opening. The other lip of the opening is formed by a fold in the base of the leaf blade for a part of its length and the balance by the edge of the petiole. The petiole is twisted so that the flattened portion lies in nearly the same plane as the leaf blade instead of at right angles to it as in normal leaves. It is clear that almost the entire gall is made up of the much enlarged and twisted petiole. The mouth is usually full-lipped and extends more or less in a spiral fully ⅔ the distance around the gall. Many times there is a small round opening at some point along the lips through which the winged lice escape. The senior author has collected aphids which correspond in every respect to *P. p.-caulis*, from galls similar to those produced

*The material described was collected, in 1913, at Salt Lake City.

by *P. p.-venæ*, at Oak Park, Minnesota, and in the Bitter Root Valley in Montana. These were from *Populus balsamifera* trees heavily infested with *P. p.-globuli* and *P. p.-venæ*. It seems that under certain conditions at least *P. p.-caulis* produces galls on the leaf similar to those produced by *P. p.-venæ*.

This aphid was very abundant in Logan during the spring of 1925. The infestation was so severe that by July 1st many leaves had fallen from the infested poplars, *Populus balsamifera* and *P. deltoides*. About 3 per cent of the leaves remaining on the trees were infested with galls.

The aphids are ordinarily very numerous in these galls, and sometimes a hundred or more pupal nymphs and winged females in addition to the stem-mother are present in a single cell. Ordinarily, there is a large drop of liquid in the bottom of the gall. The waxy material secreted by the wax glands makes the inside of the gall grayish so that when it is opened, the moving aphids appear to be mixed up in a growth of fungus.

In addition to being present in Logan, this aphid was also found in Big Cottonwood Canyon, Utah, on June 29, 1925, where it was producing its characteristic galls. It has also been collected at Hyde Park during early July, 1928.

Pemphigus populi-globuli Fitch.

DESCRIPTION.

Fundatrix:

Color.—Pale yellowish-white when mature. Antennæ, coxæ, legs, second and third joints of beak brownish. Tip of beak brown.

Wax pore plates normal for the genus; head, none; prothorax, 4; meso- and meta-thorax and abdominal segments I to VI, each with 6; segment VII, 2. Marginal plates and those on segment VII larger than the others.

Dimensions.—Total length about 2.5 mm.; width about 1.9 mm.; relative length of antennal joints: I, 3.5; II, 3.5; III, 8; IV, 6.5. Joints III and IV faintly imbricated. Imbrications consist of slightly raised ridges bearing rows of very small spines on tubercles. A few large curved hairs on at least III and IV. Permanent sensoria on distal extremity of III and at base of the weakly defined spur on VI fringed with cilia. Relative length of fore femora, 17.5; tibia, 15.0; tarsus, 7; middle femora, 20.5; tibia, 18; tarsus, 7; hind femora, 29.0; tibia, 26; tarsus, 8.

Fundatrigenia (Summer migrant).

Color.—The entire insect is lightly dusted over with a whitish powder which gives it a bluish tinge. Head and thorax dark, almost black. Abdomen greenish-gellow. Antennæ, coxæ, and legs dusky brown.

Posterior margin of stigma with a broad dusky band. Wing veins slightly dusky to brownish.

The venation is normal for the genus. The first and second discoidals of the forewing with bases normally widely separated, very rarely arising from nearly the same point. Basal one-fourth to one-third of third discoidal obsolete. Stigmal vein curved, well developed. Diagonals of the hind wing normally with bases widely separated; rarely arising from nearly the same point.

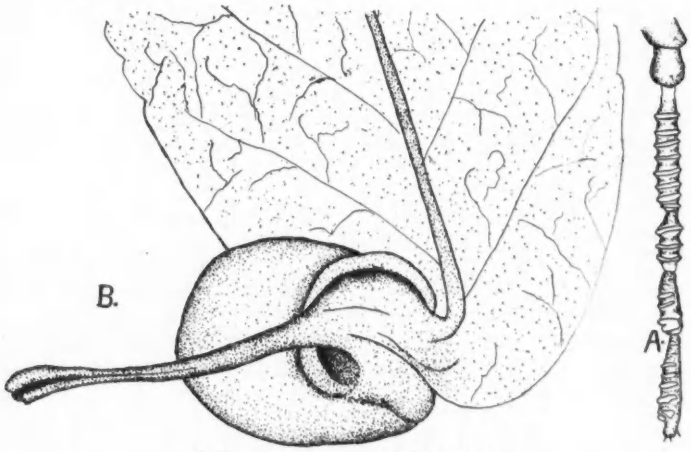


Fig. 4. *Pemphigus populi-globuli* Fitch.
A, antenna of spring migrant; B, gall on narrow-leafed cottonwood.

Dimensions.—In most collections a few small specimens occur. The following measurements are for average individuals. Total length about 1.83 mm.; abdomen about 0.7 mm. wide. Forewing about 2.61 mm. long and 0.95 mm. wide. Hind wing about 1.8 mm. long and 0.54 mm. wide at widest point. Stigma 0.53 mm. long and 0.19 mm. wide at point where vein is attached.

Antennæ 6-jointed. Sixth joint with a short unguis. Joints III, IV, V, and VI with transverse secondary sensoria annular. Secondary sensoria rarely encircling the joints. Permanent sensoria at distal extremity of V and at base of spur on VI oval, fringed with cilia. Joint III with 6-13 sensoria, most frequently 10-11; IV with 2-4, most frequently 3; V with 2-4, most frequently 3; VI with 3-7, most frequently 5.

Relative length of joints I, 3.5; II, 3.5; III, 9.5; IV, 4.5; V, 5.5; VI, 9.25. The length of the antennal joints is quite variable even of the antenna of a single individual.

Relative length of fore femora 25; tibia, 29; tarsus, 7.5; middle femora, 20; tibia, 29; tarsus, 8; hind femora, 28; tibia, 39; tarsus, 10.

Coefficient of joint VI greater than antennal coefficient. More than 60 per cent of joints IV with less than 4 sensoria.

The Galls.—The galls are usually semi-globular. Not infrequently they are more or less cone-shaped. Normally located galls are situated at the base of the leaf, on its upper side. The color is green, or when exposed to the sun, tinged with reddish varied with yellow. The gall is composed of a much enlarged and thickened portion of the leaf blade. On the under side there is a somewhat curved mouth-like orifice bounded on one side by the much thickened midrib and on the other by a thickened fold in the leaf blade. A more or less broken portion of the blade usually extends along this fold nearly the entire length of the mouth.

Many times the blade of the leaf stands at an angle to the petiole. The opening in the gall is rarely equal to one-half the circumference of the gall and is not visible from above. The lip-like borders of the opening are frequently quite rough. Galls located at some distance from the base of the leaf and resembling those produced by *P. p.-venæ* sometimes occur, especially on heavily infested trees.

This aphid is frequently encountered in Utah, on balsam poplar, *Populus balsamifera*. It has been collected in this state from Big Cottonwood Canyon, Blacksmith Fork Canyon, Farmington, Hyde Park, Providence, and Salt Lake City. The material described was collected at Salt Lake City.

Pemphigus populi-transversus Riley.

This aphid has, as its summer host, plants belonging to the family Cruciferæ. Jones states that *Populus balsamifera*, *P. monilifera*, *P. trichocarpa* and *P. fremontii* have been men-

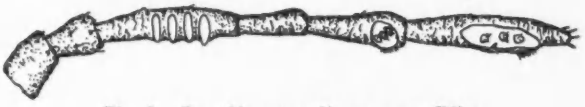


Fig. 5. *Pemphigus populi-transversus* Riley.
Antenna of spring migrant.

tioned as hosts. He also gives cabbage, turnip, mustard (*Brassica nigra*), cauliflower, broccoli, (*B. oleracea botrytis*), Brussels sprouts, rape, and several weeds belonging to the family cruciferæ as hosts of the subterranean forms. While this aphid has been reported as damaging certain cruciferous crops in the south, no damage in the northern portions of its range has been reported.

In Utah this aphid was collected at Farmington, on June 28, 1923. At this time spring migrants and pupal nymphs were present in galls formed on the petiole near the leaf of cottonwood, *Populus deltoides*. Galls and stem-mothers apparently of this species, were collected at Santa Clara by Dr. H. J. Pack, during June, 1928.

Pemphigus populi-venæ Fitch.

Pemphigus populi-venæ was described by Dr. Asa Fitch in 1859. Since the original description was published, this species does not appear to have been recognized but appears to have been confused by some aphidologists with *P. p.-caulis* and *P. p.-globuli*.

In his studies of this species Dr. Fitch appears to have failed to recognize the real nature of the aphids in the galls. It seems altogether probable that his male and female larvæ and pupæ were the early stages of the alate females (fundatrigenia).

The winged individuals were so briefly described by Fitch that the description is valueless for purposes of identification. Identifying aphids by the plant deformities produced is very apt to lead to confusion. Easily distinguished species produce very similar deformities and a single species may produce more than one form of deformity.

The Galls.—Dr. Fitch describes the galls of *P. p.-venæ* as " . . . . an oblong compressed excrescence like a cock's comb, of a light red color varied with pale yellow growing from the midrib of balsam poplar leaves on their upper side with an orifice on the opposite side. They are nearly semicircular and half as high as long, being usually over a half inch in length, with uneven surface, their walls thick, brittle and succulent . . . . They are commonly placed near the base of the leaf but sometimes in its middle."

Galls similar to those described by Fitch were collected by the senior author at Oak Park, Minnesota, on balsam poplar and near Spreckles, California, on *Populus trichocarpa*.

The aphids from these galls have some of the characters of *P. p.-caulis* and *P. p.-globuli* but are not wholly like either.

The most noticeable difference between *P. p.-venæ* and *P. p.-caulis* and *P. p.-globuli* is its smaller size. Dr. Fitch gives the length of *P. p.-caulis* as 2.54 mm. (0.10 inch), *P. p.-globuli*,

1.77 mm. (0.07 inch) and *P. p.-venæ*, 1.27 mm. (0.05 inch). The senior author has taken all three species on a single balsam poplar tree in Minnesota. The length of average-sized individuals in the collection is: *P. p.-caulis*, 1.84 mm.; *P. p.-globuli*, 1.79 mm.; and *P. p.-venæ*, 1.18 mm. *P. p.-caulis* from California measured 1.86 mm.; *P. p.-globuli*, 1.79 mm., and the aphids from the *P. p.-venæ* type of gall, 1.25 mm. Because of the similarity of the size of these species to those described by Dr. Fitch and the likeness of the galls of *P. p.-venæ* as described by Dr. Fitch to those collected in Minnesota and California, the aphid here described is considered the *P. p.-venæ* of Fitch.

Description.

Fundatrix:

Color.—Yellowish green.

Dimensions.—Total length about 1.91 mm.; width 1.34 mm.; relative length of antennal joints: I, 3; II, 2; III, 4.5; IV, 5. Joints III and IV faintly imbricated. Imbrications consist of slightly raised ridges bearing rows of very small spines on tubercles. A few rather large curved hairs on joints III and IV and at base of the weakly defined spur on IV fringed with ciiia. Relative length of fore femora 13.5; tibia, 12; tarsus, 5.5; middle femora, 15; tibia, 17; tarsus, 6; hind femora, 19; tibia, 17; tarsus, 6.

Fundatriginia (Summer migrant).

Color.—The color of the living insects is similar to that of other *Pemphigus* species producing galls on the cottonwood and balsam poplar. The light covering of whitish powder gives the insect a bluish tinge. The head and thorax are dark, almost black; coxæ, legs and antennæ brownish. Wing veins dusky; stigma dusky with a darker band along the posterior margin.

Dimensions.—Total length about 1.25 mm.; abdomen about 0.52 mm. wide; forewing 1.96 mm. long, 0.71 mm. wide; hind wing 1.47 mm. long, 0.46 mm. wide. Stigma 0.41 mm. long and 0.12 mm. wide where vein is attached. The wing venation is normal for the genus. The bases of the first and second discoidals of the forewing normally well separated, rarely arising from near the same point. The basal one-fourth to one-third of the third discoidal obsolete. Stigmal vein curved, well developed. Bases of diagonals of hind wing range from rather widely separated to arising from nearly the same point. The venation appears to be a mixture of that of *P. p.-caulis* and *P. p.-globuli*.

Relative length of fore femora 21; tibia 22; tarsus 7; middle femora 13; tibia 22; tarsus 7; hind femora 22; tibia 29; tarsus 9.

Antenna 6-jointed. Segment VI with a short unguis. Relative length of joint I, 3; II, 3; III, 8.5; IV, 4.5; V, 5.5; VI, 9. The length of the antennal joints is quite variable. In some individuals III is longer than VI, while VI is the longest in the majority of cases. Sensoria

on joints III, IV, and V, and VI annular; secondary sensoria rarely encircling the joints. Permanent sensoria at distal extremity of V and at base of spur on VI more or less oval, fringed with cilia. Joint III with 7-10 sensoria, most frequently 8-9; IV with 1-4, most frequently 3; V with 2-5, most frequently 3; VI with 3-7, most frequently 5.

Relative magnitude of antennal coefficient and coefficient of VI variable but most frequently the coefficient of VI slightly exceeds that of the antenna.

The Gall.—Dr. Fitch's description of the gall should be enlarged by stating that the galls vary in form from more or less oblong to semicircular and even almost triangular in outline. On heavily infested trees galls occur on both sides of the leaf. When on the underside they may be confused with those of *P. betæ*, being similar in form and location.

Aphids collected at Hyrum, Utah, on June 20, 1926, seem to be the species described by Fitch. These aphids were producing galls on the leaves of the narrow-leaved cottonwood, *Populus angustifolia*.

Pemphigus populi-ramulorum Riley.

While this species was described from material collected on *Populus balsamifera* it occurs commonly on *Populus deltoides* in localities outside the range of the balsam poplar. This species resembles quite closely both *P. p.-caulis* and *P. p.-globuli*. The most distinctive character is the number of sensoria on joint V of the antennæ and the relative lengths of IV and V. Normally joint V has fewer sensoria than IV. Joint V is very often shorter than IV or equal to it in length. Less frequently V exceeds IV in length.

This aphid is frequently encountered in Utah and is particularly interesting because of the gall it produces on the young twig bark of poplars, especially *Populus balsamifera*. Collections made at Leeds, both from twig galls and from galls below the bases of the leaves on the petiole, indicate that this one species produces two types of galls. This is a rather uncommon occurrence among gall-forming aphids. The openings to the leaf galls are often slightly beaked, and the mouth does not always open along the same axis, which gives variation in appearance to the openings of different galls.

In Utah this species has been collected from Benjamin, Benson, Farmington, Holliday, Hooper, Leeds, Provo, St. George, Santa Clara, and Zion National Park.

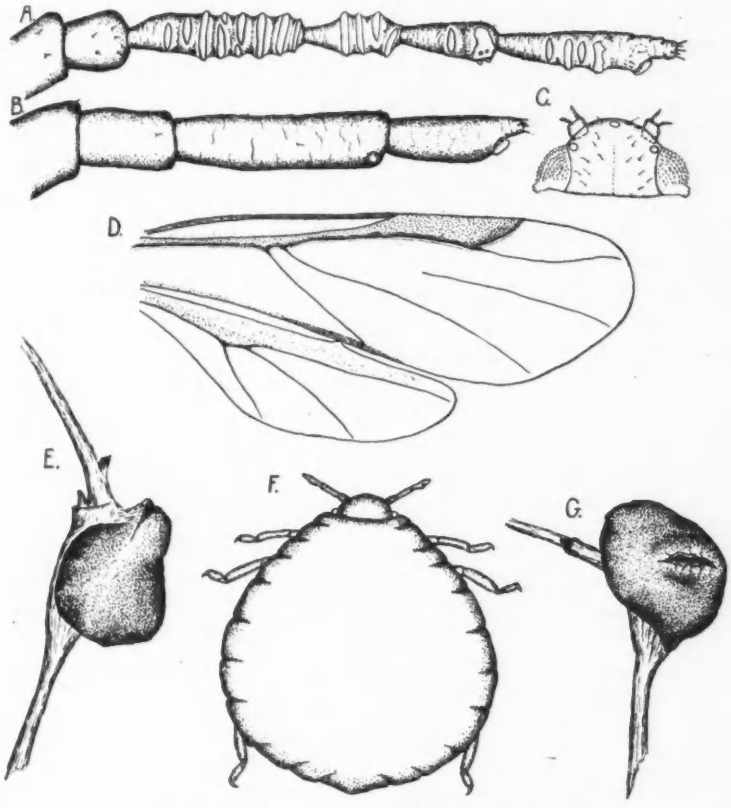


Fig. 6. *Pemphigus populi-ramulorum* Riley.
A, antenna of spring migrant; B, antenna of stem mother; C, head of spring migrant; D, wings of spring migrant; E and G, twig galls; F, stem mother.

Pemphigus betæ Doane. (*The Sugar-beet Root-Louse*)

A pemphigid from beet roots grown at Pullman, Washington, was named "*Pemphigus betæ*" and described by Doane in 1900. In 1910 Williams described *Pemphigus balsamiferae*. This aphid was taken at Squaw Creek, Nebraska, on *Populus balsamifera*. In 1914 the senior author discovered that the sugar-beet root-louse in Colorado is the summer and fall genera-

tions of *P. balsamiferae* from the narrow-leaved cottonwood, *Populus angustifolia*. Unless the beet is the host of two Pemphigus species and the one in Washington is different from the one feeding on beets in Colorado, *P. balsamiferæ* Williams, becomes a synonym of *P. betæ* Doane. In this discussion *P. balsamiferæ* is considered the spring form of *P. betæ*.

P. betæ occurs on the balsam poplar within the western range of this tree and on *Populus angustifolia* where this tree occurs naturally. Its galls are located on the underside of the leaf. They may easily be confused with the galls of *P. p.-venæ*. The aphids are easily separated, however, since *P. betæ* (*balsamiferæ*) has no secondary sensoria on joint VI of the antennæ.

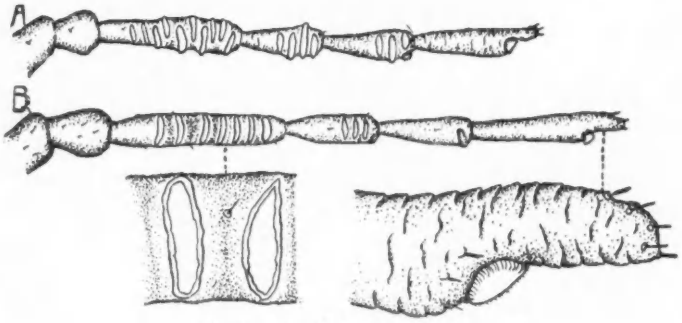


Fig. 7. *Pemphigus betæ* Doane.
A, antenna of spring migrant; B, antenna of fall migrant.

Very rarely there may be one or two very small secondary sensoria on VI. These are not noticeably raised above the surface of the joint and are never equal to the diameter of the joint in length.

The following unpublished chapter in the life history of *P. betæ* was worked out by the senior author in 1921.

Hibernating aphids were collected from the soil November 2d. These were confined in salve boxes in a greenhouse under ordinary greenhouse temperatures. The aphids collected November 2d. are designated the first generation. The second generation (young of the hibernating lice) appeared December 31st after nearly 2 months' inactivity on the part of the hibernating individuals. The third generation appeared January 21st; the fourth generation, February 24th; the 5th, March 12th; the 6th, March 24th; the 7th, April 8th, and the 8th, April 29th.

The age of the various generations when reproduction began was: second generation, 21 days old; third, 34 days; fourth, 16 days; fifth, 12 days; sixth, 15 days; and seventh, 21 days. The variation in ages is probably due to variations in temperature and the condition of the food supply. Low temperatures retard development and high temperatures quicken it.

The first, second, third, fourth, and fifth generations were all apterous viviparous females which began reproducing immediately upon becoming mature. The first alate forms (sexuparæ) appeared in the sixth generation. The sixth and seventh generations were composed of about equal numbers of apterous viviparous females and alate sexuparæ. The apterous females of the sixth and seventh generation began to reproduce as soon as mature. The offspring of the sixth generation were of four kinds. Those of the apterous forms were apterous viviparous females and sexuparæ; those of the sexuparæ, true males and females. The offspring of the seventh generation (the eighth generation) were of four kinds also. Those of the apterous viviparous females were apterous forms and sexuparæ. The former ceased feeding and became inactive upon reaching mature size. They sought out crevices in the soil where they became completely covered with the wax secreted by their wax glands. Those of the sexuparæ were true males and females. The hibernating forms of the eighth generation differ from the apterous forms of the sixth and seventh generations, since upon reaching sexual maturity they produce only apterous forms.

This change into hibernating forms appears to be biological function and not a temperature reaction.

Control.—Rotation does not reduce sugar-beet root louse infestation. In fact, beets following beets are usually less heavily infested than beets following alfalfa or small grain. In the latitude of Denver, Colorado, migration from the cottonwood to the summer host takes place during the last two weeks of June. Parker has shown that near Billings, Montana, soil moisture is a determining factor in beet root-louse development and infestation. Heavy rains during this period have the same effect.

This aphid is frequently encountered in the beet fields throughout Utah. At times it is present in damaging numbers,

causing the beets to be unthrifty. In extreme cases, the beets become shrunken and flexible, and the tops become yellowed.

Badly infested beet roots are easily pulled, and have a grayish, mouldy appearance. This grayish substance is a secretion from the wax pores of the bodies of the aphids. The yellowish wingless aphids (and during late summer and fall some darker winged forms) are found under this flocculent material. The winged aphids are frequently abundant in the beet fields of Utah during September and less numerous during August and October. During the fall this aphid occasionally becomes abundant on narrow-leaved poplars. The aphids migrate from the beet fields to this tree, and here the overwintering eggs are laid. During the next spring the eggs hatch, and the nymphs develop into the broad abdomened stem-mothers. These wingless females produce the galls on the leaves on which they feed, and in this gall the second generation develops and acquires wings, before returning to the beet fields.

Hibernating aphids have been encountered several times at Lewiston and Amalga, Utah, in early spring, following a year of heavy infestation.

The aphid several times has invaded the experimental greenhouses at Logan, when beets were being grown. In one instance, when a high humidity had been maintained for several weeks, the aphids established on the petioles and leaf-blades of the sugar-beets, many aerial colonies which were almost entirely covered by the grayish waxy secretions.

This aphid has been collected in Utah from the following localities: Amalga, Benson, Brigham, Collinston, Cornish, Delta, Garland, Hoytsville, Hyde Park, Lehi, Lewiston, Logan, Madison, Millville, Richfield, Richmond, Salt Lake City, Smithfield, and Trenton.

Prociphilus fraxinifolii (Riley).

Prociphilus fraxinifolii differs from typical *Prociphilus* species in the nature of the individuals composing the various generations. The following observation was made by the senior author at Longmont, Colorado, in 1925.

A young white ash tree in one of the city parks was very heavily infested with *Proc. fraxinifolii* on June 18. At this time many first instar lice were travelling from the infested tips

of the branches toward the trunk of the tree. Upon reaching the trunk, these young lice travelled up or down until another branch was reached, when they started toward its tip. It was thought that the migrating lice might be in search of fresh leaves upon which to locate.

At the time of observation some curled leaves contained stem mothers and many large mature apterous females which were giving birth to the young already mentioned. Others contained only a limited number of these young.

A cluster of curled leaves containing the stem mothers and apterous females was removed and fastened to a branch of a young ash tree that had no curled leaves. Immediately the young were observed travelling toward the trunk of the tree. The second day after the curled leaves were placed on the young tree, the leaves of nearly every branch below the point where the curled leaves were attached were badly curled.

Fig. 8. *Prociphilus fraxinifolii* (Riley).
Antenna of spring migrant.

On the fourth day no leaves above the point where the curled leaves were attached to the branch were curled. The migration of young, therefore, appears to be mainly downward. The third and fourth day after the curled leaves were placed on the young tree they were completely dry and the mature lice in them were dead. Apparently the stem mothers and second generation apterous females do not migrate.

This observation indicates that the sequence of generations of *Proc. fraxinifolii* is somewhat similar to that of *Eriosoma* species. No winged individuals were secured. It is believed that the winged lice are produced by the migrating generation (the young of the second generation), and, therefore, belong to the fourth generation.

Fall migrants, collected October 23, 1908, were examined by the senior author through the courtesy of J. J. Davis. They are very similar to the alate forms produced on the ash. The principal difference is in the number of sensoria on the antennal joints. The summer migrants have about 8 sensoria on III, 5 on IV, 6 on V, and 4 on VI. The sexuparæ have 2 to 3 on III, 2 to 3 on IV, 2 or 3 on V, and 1 or 2 on VI.

THE ASILIDÆ OF CUBA (DIPTERA).

S. W. Bromley.

INTRODUCTION.

The present paper is the outcome of a study of the Asilid fauna of Cuba, begun in 1926, during the writer's visit to this beautiful and interesting island.

The collecting done by the writer was confined to the western part of the island, principally in Habana province in the characteristic red clay ("tierra colorada") country. Most of this region has been under cultivation or grazing for several hundred years and many of its natural features have been lost. The Royal Palm characterizes this region, in some places forming almost pure stands.

Asilidæ do not appear in numbers in this region until about the middle of April. During May and June, they form a very conspicuous and characteristic feature of the Dipterous fauna. As the writer left before the first of May, the best collecting was missed, but through the kindness of Mr. S. C. Bruner, Entomologist at the Estación Experimental Agronómica, Santiago de las Vegas, the loan of the Station collection of Asilidæ was obtained which, together with a collection purchased from Sr. Fermin Cervéra, of Habana, formed a nucleus for the study of the Asilidæ of this region. The Station collection contained many interesting forms, many of which were collected by Sr. Julián Acuña in Camaguey Province.

Mr. Nathan Banks of the Museum of Comparative Zoology, Cambridge, Mass., kindly loaned me material from the Loew Collection, as well as other material in the Museum of Comparative Zoology collected by Messrs. Salt and Barbour. Additional specimens were loaned by Dr. Ramsden of Guantanamo, Cuba and by Mr. C. W. Johnson of the Boston Society of Natural History, while Dr. J. Bequaert kindly presented me the specimens collected by him in Cuba in 1926.

To all these workers, the writer wishes to express his thanks and appreciation. To the staff of the American Museum of Natural History the writer is particularly grateful for the use of the library and other timely assistance.

While in Habana, the writer had the opportunity of examining the famous Gundlach collection. The family Asilidæ is well represented in this collection, which is at the present time housed in the Instituto de Segunda Ensenanza de La Habana at Zulueta and San José Streets. The collection is contained in small glass-topped boxes which have been sealed, so that only superficial observation through the glass may be made. The specimens are well mounted and in excellent condition.

In the course of collecting, many specimens were taken with prey, by Mr. Bruner. Some mention is made of the species taken by various robber flies in the present paper, but detailed data is being saved for another publication.

Unless otherwise stated, the types of the new species described are in my own collection.

Key to the Subfamilies.

A. Marginal cell open.
  B. Palpi one-jointed; small, slender species; antennæ with slender terminal arista.....LEPTOGASTRINÆ
  BB. Palpi two-jointed; antennæ with or without a thickened terminal style.....DASYPOGONINÆ
AA. Marginal cell closed.
  C. Antennæ with or without a terminal style, never a terminal arista; palpi two-jointed.....LAPHRIINÆ
  CC. Antennæ with slender terminal arista; palpi one-jointed, ASILINÆ

LEPTOGASTRINÆ.

Leptogaster Meigen.

Typical Species: *L. cylindricus* DeG;—Europe.

Key to the Species.

1. Hind tibia long and slender; dark brown.....*obscuripes* Loew
   Hind tibia shorter and stouter; distinctly banded..... 2
2. Hind tibia light yellow with a median and an apical black band, *venustus* new species
   Hind tibia dark brown with broad light-reddish brown median band, *cubensis* Bigot

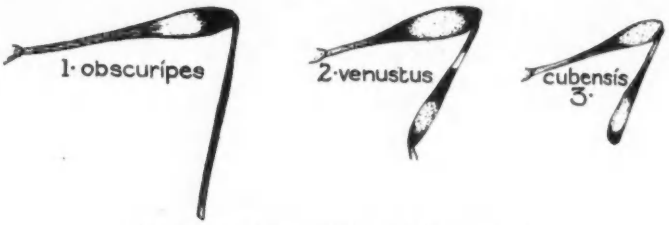
Leptogaster obscuripes Loew.

(Plate I, Fig. 16).

Leptogaster obscuripes Loew. Berlin, Ent. Zeitschr. VI, 191, 13, (1862); Aldrich, Cat. N. A. Dipt. 254 (1905); Kertesz, Cat. Dipt. IV, 55, (1909).
Leptogaster ramoni Jaennecke, Abhandl. Senckenberg. Naturf. Ges., VI, 354, 56, (1867).

Total length 10–15.5 mm. A dark-colored, slender, elongate species with the hind tibia long and slender and nearly uniformly dark brown, only the base and extreme tip being slightly lighter than the rest of the tibia. Text Fig. 1.

First two segments of antennæ reddish, 3rd and arista black. Mystax sparse, white. Proboscis dark brown. Face silvery pruinose. Palpi brown. Thoracic dorsum reddish brown with a median black stripe and two dark lateral lines separated from the median stripe by two white pruinose streaks, one on each side. Pleura silvery pruinose. Wings hyaline, iridescent. Halteres pale brown. Scutellum dark brown. Legs brownish, the anterior pair lightest and nearly uniformly colored. The middle pair darker, the femur and tibia with the apex lighter. The hind pair very long, dark brown; a light band at the distal portion of the femur which is slightly swollen; the extreme tip of the tibia and tarsus lighter, but with the distal tips of the tarsal segments nearly black. Abdomen long, slender, dark brown, the incisures very slightly lighter. The distal portion of the 8th segment and genitalia in the male are enlarged.



Posterior Femur and Tibia in Leptogaster.

Fig. 1, *Leptogaster obscuripes* Loew. Fig. 2, *L. venustus* n. sp. Fig. 3, *L. cubensis* Bigot.

Jaimanita, Habana, VIII, 1912 (Cervéra). Banes, March 21, 1926 (Bequaert). Soledad, 8–11, '25 and 26-V, '25 (Salt). Other specimens, unlabeled, probably from vicinity of Habana (Cervéra). One specimen with the detached head of a small ant clinging to the hind tarsus.

Leptogaster cubensis Bigot.

Gonypes cubensis Bigot. Sagra's Hist. de La Isla de Cuba, p. 2, VIII, 332, (1856).

Length 9 mm. A small slender, grayish species with leg markings as in Fig. 3.

One specimen, a female, Habana, June 5, 1922. Coll. S. C. Bruner.

Leptogaster venustus new species.

Length 7–11 mm. Leg markings as in Fig. 2.

Male. Face, vertex, and occiput grayish pollinose. Antennæ (3rd segment black), palpi, and proboscis brownish. Mystax composed of 3 or 4 fine white bristles. Thorax brownish-gray, pleura white

pollinose. Two black bristles on mesonotum above each wing. Disc of mesonotum with three brownish lines. Scutellum grayish pollinose. Wings hyaline. Halteres pale yellow, knobs light brown. Legs yellowish with yellowish bristles. All femora and tibiæ brownish at tip. Front tibiæ, middle femora and tibiæ with brown mark on median anterior aspect. In all tarsi the first segment is very pale yellow; the other segments darker. Hind tibia banded as follows: basally light yellowish-brown; followed by a white band; then the median dark brown band, then a yellowish-brown band and finally the apical brown band. Abdomen grayish brown, the segments with pale posterior margins. Genitalia rather large; the forceps hooked, curved in at tips.

Female. Similar. The abdomen is more clavate; the 1st 4 segments narrow, the 5th widening, the 6th and 7th of equal width.

Holotype, male. Cuba, Gundlach (Loew Collection) 128–258 in M. C. Z. Allotype, female, Camaguey, Cuba. (J. Acuña, Coll.), Aug. 20, 1924. Paratypes ♂♂, Camaguey, Cuba, (J. Acuña Coll.), Aug. 20, 1924. Soledad, Cuba, May 4, 1925, (Geo. Salt). ♀♀, Camaguey, Cuba (J. Acuña Coll.), Aug. 20, 1924; Soledad, Cuba, June 20, 1925, (Geo. Salt).

This species bore Loew's manuscript name *venustus* which I have adopted.

Leptogaster clavipes Johnson (Ent. News VIII, 120. 1897) described as *longipes* (praeoc.) Acad. Nat. Sci. Phil. 273. 1894 from Jamaica has not as yet been recorded from Cuba.

DASYPOGONINÆ.

Key to the Genera.

A. Front tibia without a terminal claw-like spur.
  B. Eyes closely approximate at top of head; elongate slender species ..... *Plesiomma*
  BB. Eyes well separated at top of head; stouter species; front and middle femora with a patch of short, stout bristles below .. *Sphageus*
AA. Front tibia with a terminal claw-like spur.
  C. Posterior pulvilli much shorter than the elongate claws; scutellum without bristles ..... *Blepharepium*
  CC. Posterior pulvilli not much shorter than the claws; scutellum with bristles ..... *Deromyia*

Plesiomma Macquart.

Typical Species: *P. testacea* Macquart—S. America.

Key to the Species.

1. Large black species ..... *funnestum* Loew
   Yellowish brown species 2
2. Wings brownish or smoky with pale yellowish areas in middle 3
   Wings uniformly hyaline or smoky 4

3. Dorsum of thorax with three distinct black stripes, the middle one nearly uniform in width, 11–16 mm.....*lineatum* Fabricius
   Thorax less distinctly marked with brown, the median stripe broadening anteriorly, 18–25 mm.....*indecorum* Loew
4. Wings slightly darker toward costa; anterior branch of 3rd vein without a stump vein.....*leptogaster* Loew
   Wings uniformly smoky; anterior branch of 3rd vein with a stump vein.....*salti* new species

All of the Cuban species examined by the writer have the mystax composed of only one row of bristles. The Mexican species have more than one row of bristles in the mystax.

Plesiomma funestum Loew.

Plesiomma funesta Loew, Wien. Entom. Monatschr. V, 35, 6, (1861).
Plesiomma funestum Kertesz, Catal. Dipt. IV, 145, (1909).
Dioctria lugubre Jaennecke, Abhandl. Senchenberg. Naturforsch. Ges. VI, 356, 59, (1867).

Length 28–30 mm. A large beautiful species, deep black. The wings are black with a blue-green lustre. The first two pairs of legs or in some cases only the anterior pair are reddish-yellow.

Three males, Sierra Rangel, Pina del Rio, Cuba, Aug. 29, '27. Elevation 1,500 ft. Collected by J. Acuña and S. C. Bruner.

This species, the largest of the genus in Cuba, is undoubtedly memetic of the tarantula hawk, *Pepsis ruficornis* LeP.

Plesiomma lineatum Fabricius.

Asilus lineatus Fabricius, Species Insect. II, 465, 28, (1781).
Dasypogon lineatus Fabricius, Systema Antliat. 167, 13, (1805).
P. macra Loew. Wien. Ent. Monatschr. V, 25, 5, (1861).

Two males of this species are at hand, one from La Milpa, Cuba, (Cienfuegos) July 4, 1925, (Geo. Salt) and San José, Matanzas, Cuba, Aug. 16, 1927, collected by J. Acuña.

Plesiomma indecorum Loew.

(Plate I, Fig. 12).

Plesiomma indecora Loew, Berlin. Ent. Zeitschr. X, 19, 33, (1866).
Plesiomma longiventre Schiner, Verh. Zool. Bot. Ges. Wein. XVII, 375, 38, (1867).

Length: 19–26 mm. A large yellowish brown species, evidently the most common Cuban representative of the genus. A very pale specimen in the Loew collection bears the manuscript name "hypoxantha" but I do not think it is sufficiently distinct to be considered as a different species.

Specimens at hand from Habana Province; Vicinity of Habana, (T. Barbour); Santiago de Las Vegas, May 29, 1926;

June 16, 1926; July 15, 1926 (S. C. Bruner) Camaguey, July 5, 1925 (J. Acuña); Soledad June 2, 1925 (Geo. Salt).

Plesiomma salti new species.

Length 17 mm. A yellowish-brown species with black thoracic lines, related to *P. leptogaster* Loew, but differing in having the head proportionately narrower, and the wings uniformly smoky in color, the anterior branch of the 3rd vein with an appendix.

Male. Head yellowish-brown, eyes black. Third joint of antennæ darker above, style black. Mystax composed of 6 bristles, pale yellowish brown. Antennal bristles of same color. Beard and palpal hairs pale yellow. Thorax yellowish-brown. Pleura with two black stripes, the first extending from behind the spiracle to the first coxa; the second from the base of the wings to the second coxa; and a black spot in front of the hind coxa. The pronotum has 2 dark brown spots above, and the mesonotum bears three black lines, the median line broadening very slightly anteriorly. The bristles of the mesonotum are dark brown anteriorly, those of the posterior portion, black. The parascutellum bears yellow bristles. The scutellum is dark brown, and bears two long marginal bristles. The legs are reddish yellow with concolorous bristles. The tips of the femora are darker as are the tips of the posterior tibiæ. The posterior femora bear a light brownish preapical ring. Wings uniformly smoky, the veins brown. Halteres yellowish. Abdomen yellowish-brown, becoming darker apically. The anterior margin of the 1st segment bears a blackish line. The second segment has a median dark area and the third segment is darker anteriorly. Genitalia small, dark yellowish brown with concolorous hairs and a few black hairs anteriorly. The hairs of the preceding segment are blackish.

Holotype, male, Soledad, Cuba, June 20, 1925, Geo. Salt in M. C. Z.

Sphageus Loew.

Typical Species: *S. chalcoproctus* Loew—Cuba.

This genus is related to *Dizonias*, from which it is distinguished by the lack of the excision on the 3rd segment of the antenna, and the undersides of the front and middle femora have a patch of stout bristles. The mystax extends nearly to the antennæ.

Sphageus chalcoproctus Loew.

Sphageus chalcoproctus Loew, Berlin Entom. Zeitschr. X, 31, 55, (1866).

Length 22 mm. A large reddish-yellow species with pile and bristles of head, thorax and abdomen, golden. The legs are reddish yellow with patches of black bristles on the underside of the front and middle femora. The thorax is black with a golden pruinosity over a considerable part of its area and the scutellum and the abdomen are

yellowish-red. The posterior margins of the abdominal segments are narrowly black. There is a whitish spot on each side of the anterior portion of segments 2–4.

A male, VII, 1922, Playa Chevo, Habana, (F. Cervéra).

Deromyia Phillippi.

Typical Species: *D. gracilis* Phillippi—Chile.

Key to the Species.

1. Three velvety black stripes on mesonotum.....*ternata* Loew
   Two median black stripes closely approximated.....*bilineata* Loew

Deromyia bilineata Loew.

Deromyia bilineata Loew, Berlin. Ent. Zeitschr. X, 23, 40, (1866).

A study of the type specimen failed to reveal any striking difference from *discolor* Loew. This species has not since, to my knowledge, been taken in Cuba. The species described by Back (Trans. Amer. Ent. Soc. vol. XXXV, p. 356, 1909) from Florida as *bilineata* is a new species and quite distinct from the type of Loew's *bilineata*. Back's original observation (p. 357) that *bilineata* is a synonym of *discolor* is, probably, correct. but I should like further material before stating definitely.

Deromyia ternata Loew.

(Plate I, Fig. 20).

Deromyia ternata Loew, Berlin Ent. Zeitschr. X, 22, 58, (1866).

Length, 19–22 mm. This is a common species in Cuba. It differs from the species generally known as *ternata* in U. S. which is a new species. The true *ternata* has the median black line on the mesonotum extending to the anterior margin and does not become reddish anteriorly as in the U. S. species. The thorax is also covered with a more intense golden pollinosity and there is a dark area on the pleura above the last two coxæ, which is missing in the U. S. species. The Cuban species is also more robust, the legs stouter and the bristles stronger.

Specimens at hand from Habana province, collected by S. C. Bruner, May, June. There is also a female from Sto. Tomás, P. de Zapata, Cuba May 5–9, 1927 collection by S. C. Bruner and J. Acuña.

Blepharepium Rondani.

Typical Species: *B. lurida* Rondani. "Patria ignota".

Blepharepium contains several South and Central American species which have generally been considered synonymous.

The genus itself has been confused with *Senobasis* to which it is entirely unrelated, its nearest affinities being with *Deromyia*. The following key points out characteristic differences between the species.

1. Posterior femora black basally; reddish or yellowish apically..... 2
   Posterior femora uniformly colored..... 3
2. Thoracic markings black.....*annulatum* Bigot (Cuba)
   Thoracic markings reddish.....*secabilis* Walker (Mexico)
3. Mostly black; proboscis black, posterior femora black or dark brown, *cayennensis* Fabr. (Guiana)
   Mostly reddish yellow; proboscis reddish; posterior femora dark reddish-yellow.....*coarctata* Perty (Brazil)

Blepharepium annulatum Bigot.

(Plate I, Fig. 21).

Senobasis annulata Bigot, Sagra's Hist. de la Isla de Cuba, p. 2, VII, 331, (1856).

Length 21–24 mm. A large yellowish species banded with black, apparently mimetic of the common large *polistes* wasps *P. major* or *cubensis*.

Specimens at hand from Habana Province collected by S. C. Bruner and from Guantanamo, collected by Dr. Ramsden. One specimen taken feeding on a worker honey-bee.

LAPHRIINÆ.

Key to the Genera.

A. Veins at outer ends of discal and 4th posterior cells parallel or nearly continuous in the same straight line.
   B. First antennal joint much more than twice the length of the second.....*Cerotainia*
   BB. First antennal joint not more than twice as long as second..*Atomosia*
AA. Veins at outer ends of discal and 4th posterior cells not parallel but forming an angle.
   B. Proboscis long, straight, slender, of uniform width; abdomen coarctate; antennæ longer than length of thorax.....*Rhopalogaster*
   BB. Proboscis short, stout at base, pointed or upturned at tip; stout, hair species.....*Andrenosoma*

Cerotainia Schiner.

Typical Species: *C. xanthoptera* Wied. "Patria ignota".

One species only is represented in the present collection.

Cerotainia laticeps new species.

(Plate I, Fig. 2).

Total length, 5 mm. A small black species, proportionally shorter and broader and with a wider head than *C. macrocera*. Dorsum of thorax with very fine appressed, bronze pubescence. Antennæ and proboscis black. Mystax scanty, white. Frons silvery pruinose.

Thorax black with very fine bronze pubescence. A patch of long white hairs in front of halteres. Femora and tarsi black; tibiæ brown except tips which are black. Legs with fine white hairs. Wings nearly hyaline with iridescent reflections. Halteres reddish. Abdomen short and broad; black with inconspicuous metallic reflections.

Holotype (♂) Sto. Tomás, P. de Zapata, Cuba, May 5–9, 1927. Collectors (S. C. Bruner and J. Acuña). Allotype, ♀, Cuba (Priehl) Loew collection, Mus. Comp. Zool. Paratypes, Herra Dura, Cuba, collected by Metz and received from C. W. Johnson. Soledad, Cuba, June 8, 1925 (Geo. Salt). Sto. Tomás, P. de Zapata, Cuba, May 5–9, 1927 (S. C. Bruner and J. Acuna); Camaguey, Aug. 20, 1924 (J. Acuña) (feeding on a small winged ant) and a damaged specimen from the Loew collection marked 3/130.

The Priehl specimen (Loew collection) bears the manuscript name *laticeps* which I have adopted for the species.

Atomosia Macquart.

Typical Species: *A. puella* Wied.—N. America.

Key to the Species.

1. Ground color of body metallic blue.....*metallica* new species
   Ground color of body otherwise..... 2
2. Hind femur mostly black..... 3
   Hind femur mostly yellowish or reddish..... 5
3. Front femur reddish.....*maestræ* new species
   Front femur black..... 4
4. Mystax white.....*incisularis* Macquart
   Mystax grayish or black.....*parva* Bigot
5. Dorsum of thorax silvery pubescent and pruinose; stout species, *pubescens* new species
   Dorsum of thorax otherwise..... 6
6. Legs mostly yellowish; thoracic dorsum light brassy pruinose..*similis* Bigot
   Legs nearly uniformly reddish; small species.....*cerverai* new species

Atomosia incisularis Macquart.

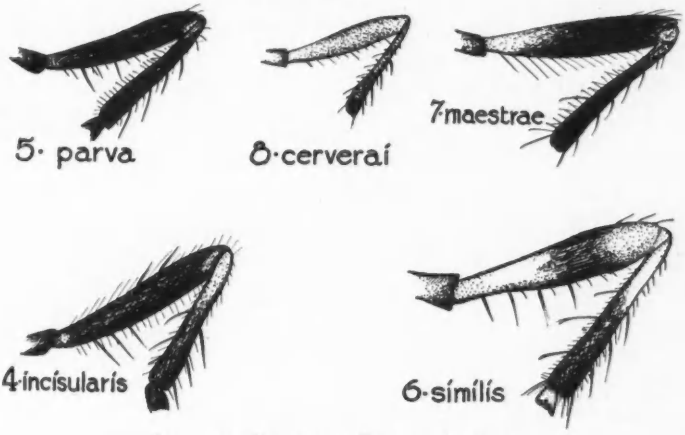
Atomosia incisularis Macquart, Dipteres Exotiques I, 2, 76, 4, (1838).

A small (7 mm.) black species related to *A. puella* Wied. The mystax, beard, face and front is white, the legs black and fuscous as represented in Fig. 4. The first posterior cell is usually open although narrowed at the margin, but in one specimen this cell is closed. There are some white bristles on the posterior tibiæ.

Several specimens from the Loew Collection one bearing the date Habana, Dohrn, others bearing the label "Poey." One specimen has the 1st posterior cell closed at the margin and bears Loew's MS name "clausa."

A specimen from Santiago de Las Vegas, May 19, 1916; another from Soledad, June 20, 1925 (Geo. Salt).

This species and the following seem to be very closely related and a large series of specimens may prove the next to be simply a variety of *incisularis*.



Posterior Femur and Tibia in Atomosia.

Fig. 4, *Atomosia incisularis* Macq. Fig. 5, *A. parva* Bigot. Fig. 6, *A similis* Bigot. Fig. 7, *A. maestrae* n. sp. Fig. 8, *A. cerverai* n. sp.

Atomosia parva Bigot.

(Plate I, Fig. 8).

Dasypogon parvus Bigot, Sagra, Hist. de La Isla de Cuba, p. 2, VII, 330, (1856).

A small black species, averaging slightly smaller than *incisularis*, from which it may be distinguished by the grayish or blackish mystax, the narrower white or grayish incisures of the abdomen (usually only apparent on the posterior borders of the 4th and 5th segments), and the more uniformly piceous legs with all black bristles on the posterior tibiæ. Fig. 5.

Eleven specimens from Santiago de Las Vegas, April 20–June 11. Two from Jarahueca July 14–18, 1927, (S. C. Bruner).

Atomosia pubescens new species.

(Plate I, Fig. 3).

Total length 5.5–7.5 mm. A robust black species with broad abdomen, broadly rounded at the tip. Thoracic dorsum with thickly-set appressed white pubescence. Antennæ, proboscis, frons and palpi black. Mystax, beard, occipital and palpal hairs silvery white. Coxal

and pleural hairs also white. Scutellum with short, thick, silvery white pubescence and about 6 or 7 fine white upturned bristles along margin. Legs dull reddish with fine white hairs and bristles. The tarsi and apices of the tibiæ are brownish and there are brownish cloudings on the dorsal side of the femora becoming darker toward the apices. Wings hyaline; the first posterior cell closed at the margin of the wing. Abdomen black, punctulate, covered with very short, scattered, white pubescence. Posterior margins of each segment, except the first very narrowly white.

Holotype, ♂, Soledad Cuba, June 2, 1925 (Geo. Salt) in M. C. Z; 9 paratypes Soledad June 2–June 25, 1925 (Geo. Salt).

Atomosia maestræ new species.

Total length 8–9 mm. Slender black species with slightly fumose wings. First two segments of antennæ reddish brown; 3rd missing. Frons with silvery pubescence and bloom. Mystax thin, white; occiput with inconspicuous white bloom. Pleura whitish pruinose and apices of femoræ and of meso-tibiæ darker. Hind legs nearly black with the exception of the coxæ and bases of the femora which are yellowish (Fig. 7). Wings light grayish with iridescent reflections. Abdomen dull black, slightly constricted at juncture of 2nd and 3rd segments. Incisures narrowly white.

Holotype, ♂, Sierra Maestra, Cuba, July 10–20, 1922. (S. C. Bruner and C. Ballou) Alt. 3000–3500 ft. Allotype, ♀, Pico Turquino, Cuba July 20, 1922 (S. C. Bruner and C. Ballou).

Atomosia cerverai new species.

Total length 4 mm. A very small black species with reddish brown legs and black antennæ. Frons whitish pruinose, mystax thin, white. Occiput with inconspicuous whitish bloom. Thorax black, nearly bare. Pleura with inconspicuous whitish bloom. Wings hyaline with iridescent reflections. 1st posterior cell open. Halteres reddish. Legs reddish brown, the posterior tibiæ and tarsi darker (Fig. 8). Abdomen shining black, incisures white, rather short and broadened toward tip, slightly constricted at junction of 2nd and 3rd segments.

Holotype, ♂, Soledad, May 27, 1925, (Geo. Salt) in M. C. Z. Named in honor of Sr. Fermin Cervéra, the well-known collector and naturalist, late of Habana, Cuba.

Atomosia similis Bigot.

Plate I, Fig. 15

Atomosia similis Bigot, Sagra, Hist, de La Isla de Cuba, p. 2, VII, 332 (1856)

A black species (8-11 mm. in length), covered sparsely with fine, short whitish pubescene giving it a silvery gray appearance. The legs

are yellow with brown markings. (Fig. 6.) The first segment of the antenna is yellowish, the second and third brown. The mystax, beard, palpal hairs and fine hairs of the head are white. The bristles of the throax are yellowish. Most of the hairs and bristles of the legs are white. Wings hyaline, veins at the base yellowish.

Specimens at hand from Santiago de Las Vegas collected by Mr. S. C. Bruner and Mr. B. T. Barreto, June 2–26; Guantanamo collected by Dr. C. T. Ramsden July 25, 1915; Candelaria May 10, 1924 collected by C. H. Ballou; Sto. Tomás, P. de Zapota, May 5–9, 1927 (Bruner et Acuña).

Atomosia metallica new species.

Total length 5 mm. A slender, nearly bare, dark metallic blue species. Vestiture of head scanty, white. Frons silvery pruinose; occiput with whitish bloom and hairs. Thorax with a few scattered white hairs and a few black bristles posteriorly. An inconspicuous whitish bloom on the pleuræ and 3 long black bristles in front of the halteres. Legs yellowish with scattered dark hairs. Posterior femur with brownish pre-apical band. Apex, white. Posterior tibiæ and all tarsi brownish. Scutellum bare with two long black bristles on posterior apex. Wings hyaline with iridescent reflections. First posterior cell open. R_1 makes inward bulge near the margin of the wing where R_2 meets it, closing the marginal cell. Halteres light yellowish. Abdomen slender, nearly black with bluish reflections, gradually widening towards the tip. Finely punctulate with fine white inconspicuous pubescence. The incisures very narrowly white.

Holotype, ♂, Palma Mocha, Sierra Maestra, Cuba, July 10–20, 1922 (C. H. Ballou and S. C. Bruner); 4 paratopotypes same data.

Rhopalogaster Macquart.

Typical Species: *R. longicornis* Wied.—Brazil.

A single specimen in the collection, which was found to be a new species, is here described.

Rhopalogaster bella new species.

(Plate I, Fig. 5).

Female. Total length 11 mm., excluding antennæ which are 4 mm. in length. Rather slender, black species with petiolate abdomen. Antennæ long, black; the first segment about 1/3 the total length; second segment very small; third segment long and blade-like. Vestiture of head, including beard, mystax, pubescence of frons, etc., white. Occiput whitish pruinose. Palpi very small, proboscis long (about 1.75 mm. in length) slender. Thorax and legs black with whitish hairs. Pleura whitish pruinose. Mesonotum whitish pruinose with a median black

line and two broad lateral spots. Scutellum black with margin thickly set with fine white upturned bristles. Wings hyaline at base, slightly brownish beyond middle. 1st posterior cell closed. Legs black with fine, long, white hairs. Abdomen metallic blue with brownish incisures. Hairs of abdomen fine, white. 2nd segment long, slender and of uniform width, 3rd segment broadened posteriorly; 4th and 5th broad; 6th tapering to apex.

Holotype, ♀, Camaguey, Cuba, Aug. 20, 1924. (J. Acuña Coll.).

Andrenosoma Rondani.

Typical Species: *A. ater* (L.)—Europe.

Key to the Species.

1. Abdomen red or orange with exception of anterior and lateral margins of 1st segment which are black.....*acunai* new species
   At least half of abdomen black..... 2
2. Dorsum of 1st two abdominal segments with fine appressed white pile (ground color dark red).....*quadrimaculata* new species
   Abdomen otherwise..... 3
3. Scutellum reddish; large species (23 mm.).....*varipes* Banks
   Scutellum black or metallic blue..... 4
4. Scutellum metallic blue.....*chalybea* Williston
   Scutellum black.....*crassa* new species

Andrenosoma chalybea Williston.

(Plate I, Fig. 17).

Andrenosoma chalybea Williston. Trans. Am. Ent. Soc. XII, 56. 1885.

Blackish species with metallic blue abdomen, scutellum and legs. Mystax mostly black, a few white hairs at sides or intermingled; beard white. 12–20 mm.

Male, Taco Taco, Cuba. April 1–6, 1922 (S. C. Bruner, J. Acuña, C. H. Ballou, coll.). A large male from the Loew collection ($\frac{220}{429}$) bears the manuscript name "panthophora".

Andrenosoma varipes Banks.

Laphria varipes Banks. Canadian Entomologist 52. 67. 1920.

A large robust grayish species with dull black abdomen, the last three segments of which are red. The humeri and scutellum are also reddish as are the legs with the exception of the apical fourth of the femora and the tarsi which are black.

The type is in the Mus. Comp. Zool. labelled Cuba (Poey).

This is the largest species of *Andrenosoma* so far found in Cuba. Banks gives the length as 23 mm. There is, however, a specimen in the Gundlach collection at Habana which is considerably larger.

Andrenosoma quadrimaculata new species.
(Plate I, Fig. 19).

Male. Total length 20 mm. Black species with very hairy legs. 6th segment of abdomen and following segments reddish.

Proboscis and antennæ black. Face reddish, covered thickly with white pile. Mystax composed of thickly set, stubby, black bristles. Palpi black with black hairs. Beard white. Thorax deep reddish with two sparse median black lines and two large lateral spots on each side. The reddish areas as well as the pleuræ are covered with a silvery bloom. Hair and posterior bristles of mesonotum black. Pleuræ and coxæ thickly covered with sordid white hair. Legs black, except base of femora, and basal half of tibiæ and posterior femora which are deep red. Legs thickly covered with long fine pile, mostly white on reddish areas and black on black areas. On the anterior tibiæ a row of fine black bristles on the anterior dorsal aspect. Scutellum black with black hairs and a row of black bristles along margin. Wings hyaline at base, the apical half brownish, darkest along the veins. 1st posterior cell open. Halteres yellow. Abdomen with black hairs and bristles. Ground color of first 3 segments deep reddish; the 4th and 5th nearly black with, however, a deep reddish tint. 6th segment and following light reddish with fine reddish hairs. Genitalia with a few black bristles. The 1st two segments are covered thickly posteriorly and lightly anteriorly with short fine white appressed pile.

Holotype, ♂, Cuba (Poey), Loew collection in M. C. Z. This specimen bore the manuscript name of *quadrimaculata* which was adopted.

Andrenosoma crassa new species.
(Plate I, Figs. 11 and 13).

Length 16–21 mm. A large, robust, black species, with the usual thoracic markings on the mesonotum obscure, brownish pollinose. The 6th and following segments of the abdomen are deep brownish red.

Male. Head black; (Fig. 9), mystax, palpal hairs, antennal bristles, bristles of vertex and occiput black. Hairs on sides of mystax and face as well as beard, white. Thorax black with black hairs and bristles, the indentations brownish pollinose. Legs black with black hairs and bristles. The first two coxæ have white hairs in front and the under side of the front and middle femora and tibiæ are thickly clothed with long fine white pile. Scutellum black with black hairs and long upturned marginal bristles. Wings tinged with brownish, darkest along veins, base nearly hyaline. 1st posterior cell open. Halteres brown. Abdomen black with black hairs, the 6th and following segments deep brownish-red with reddish hairs. Genitalia with reddish hairs and black bristles.

Female. With beard somewhat blackish, and lacking the white pile on the legs. Ovipositor long and cylindrical.

Holotype, ♂, Camaguey, Cuba, Aug. 20, 1924. (J. Acuña, Coll.). Allotype, ♀, same data. Seven paratopotypes, same data.

Andrenosoma acunai new species.
(Plate I, Fig. 7).

Male. Total length 10 mm. Small black species with reddish orange abdomen.

Antennæ, proboscis and palpi black. Occiput and frons silvery pruinose. Beard and mystax white, scanty, the latter with an occasional black bristle. A pair of long fine black hairs on occelar tubercle. Palpal hairs black. Thorax black. Posterior margins, a spot in front of wing and anterior angles of mesonotum silvery pruinose. Legs black with fine whitish hairs. Tarsi with black hairs. Wings suffused with light brownish tinge; costal, 2nd basal and base of marginal cells nearly hyaline. 1st posterior cell closed at margin. Halteres yellowish. Abdomen reddish-orange, except anterior portion of 1st segment and genitalia which are black.

Holotype, ♂, Camaguey, Cuba, Aug. 20, 1924 (J. Acuña, coll.).

ASILINÆ.

Key to the Genera.

A. Arista of antenna pectinate.....*Ommatius*
AA. Arista bare.
B. Posterior branch of third vein terminating a considerable distance behind the apex of the wing.
C. Hairy, robust species; hypopygium and ovipositor small and inconspicuous.....*Mallophora*
CC. Slender species; hypopygium large and ovipositor long...*Asilus*
BB. Posterior branch of 3rd vein terminating at or before the apex of the wing (in some species of Erax very slightly behind apex).
D. Posterior branch of 3rd vein bending forward sharply before the apex of the wing; hypopygium normal in size; ovipositor cylindrical with terminal circlet of spines.....*Proctacanthus*
DD. Posterior branch of 3rd vein curved back slightly at tip; hypopygium enlarged; ovipositor long and compressed, without spines.....*Erax* (*aestuans* group)

Ommatius Wiedemann.

Typical Species: *O. marginellus* Fabricius. W. Indies.

Ommatius marginellus Fabricius.

Asilus marginellus Fabr. Species Insect. II, 464, 22, 1781 et Mantissa Insect., II, 360, 25.

A grayish species with yellowish legs, the apices of the femora and posterior tibiæ brownish. Middle and posterior tarsi brown. There is a bulge in the costa in the male. The margin of the scutellum bears two bristles which distinguishes the species from the North American species *tibialis* Say.

Specimens at hand from Habana Province and Guantanamo.

Mallophora Macquart.

Typical Species: *M. bomboides* Wied. N. America.

Key to the Species.

1. Femora reddish; 1st four abdominal tergites and all of venter with thick yellow pile.....*macquartii* Rondani
2. Femora black; 1st two abdominal tergites with light yellow or white pile; venter black.....*bruneri* new species

Mallophora macquartii Rondani.

(Plate I, Fig. 10).

Mallophora scopifer Macquart, Dipt. exot. I (2), 89, 1838, nec Wied. Auss. Zweifl. I, 478, (1828).
Mallophora scopipeda Rondani, Nuov. Annal. Sci. Nat. Bologna, 367, (1850).
Mallophora macquartii Rondani Nuov. Annal. Sci. Nat. Bologna, Sec. 3, 11, 371, 21, (1850).

Length 15–20 mm. This black and yellow, bumblebee-like species is abundant in Cuba during May and June. Specimens are at hand from Santiago de Las Vegas, and Camaguey Province collected by S. C. Bruner and others, and from Guantanamo collected by Dr. Ramsden.

This species feeds very largely on honey-bees, occasionally taking a small *polistes* or other wasp or a small scarabeid beetle. Dr. Bruner writes under date of June 5, 1928, "*Mallophora macquartii* appeared late. I did not take any until May 18, but they were probably out sooner. A few days later they were found in great numbers around the apiary, many of them were carrying honey bees. In fact, I did not see them with any other insect. They must kill a very large number of bees." In this respect they agree with our North American species, *M. orcina* Wied. and *M. bomboides* Wied., both notorious "bee-killers" in the Southern States. *Mallophora ruficauda* Wied. very abundant in the vicinity of Buenos Aires, Argentina, is recorded by Dr. Andres Copello as feeding very largely on honey-bees and a species in western U. S., *M. fautrix* O. S. also has the same habits.

Mallophora bruneri new species.

Length, 22–25 mm. A beautiful black species with whitish pile on the scutellum, the median portions of the first and second abdominal segments, occiput, beard and lower portion of mystax, quite distinct from any species previously described. All the white hairs have a faint yellowish tinge.

Female. Head black, sides of face brownish pollinose. Mystax with black bristles above and on sides, white bristles in center and below.

Bristles of antennæ and vertex, black. Palpal hairs, both black and whitish. Beard and occipital hairs whitish. Thorax deep black with black hairs, except the thick conspicuous tuft on scutellum and a tuft in front of the halteres, white. Legs piceous, the base of the tibiæ dark reddish brown, hairs and bristles black. Wings dark brown. Halteres dark brown. Abdomen deep black with black hairs. A narrow median band of white hairs on 1st and second tergites. A few white hairs on sides of 3rd tergite.

Holotype, ♀, Sierra Rangel, Pinar del Rio, Cuba, Aug. 29, Elevation 1500 ft. (in pine grove) S. C. Bruner and J. Acuña. Paratopotype, ♀, same data.

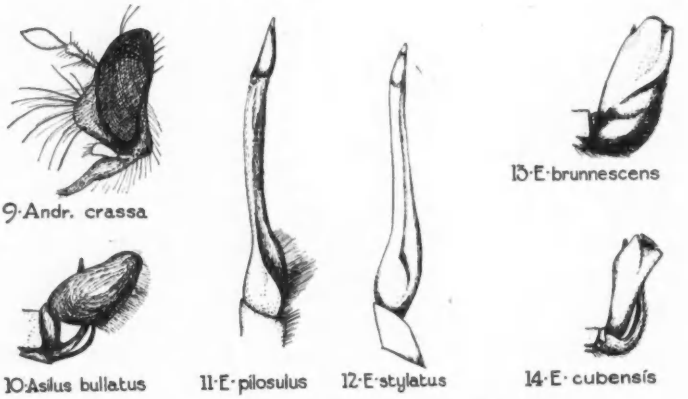


Fig. 9, Head of *Andrenosoma crassa* n. sp. Fig. 10, Male genitalia of *Asilus bullatus* n. sp. Fig. 11, Ovipositor of *Erax pilosulus* n. sp. Fig. 12, Ovipositor of *E. stylatus* Fabr. Fig. 13, Male genitalia of *E. brunnescens* n. sp. Fig. 14, Male genitalia of *E. cubensis* n. sp.

Asilus Linn.

Typical Species: *Asilus crabroniformis* L.—Europe.

Three species of *Asilus* are known to occur in Cuba. Their closest affinities seem to be with the *Pachychoeta* group of S. America. The latter is a genus bridging *Asilus* and *Erax*.

Asilus bullatus new species.

(Plate I, Fig. 14).

Length 9–13 mm. A small gray and black, *Erax*-like species with enlarged hypopygium (with tuft of white hairs below) and golden mystax in the male, and long, slender somewhat compressed ovipositor, and paler mystax in the female. In the ♂, the antennal arista is very slightly thickened preapically, but this does not occur in the ♀.

Male. Head slightly broader than thorax; antennæ dark brown; face golden pruinose, mystax golden with 2 or 3 long black bristles in upper part. Beard white. Palpal hairs, occipital bristles black. Thorax grayish pollinose, the mesonotum with a median black line and two black lateral spots on each side. Bristles black. Scutellum gray pollinose with black hairs and at least two long black marginal bristles. Coxal hairs and tuft in front of halteres pale yellowish. Legs black; tibiæ except tips, red. Wings hyaline, halteres yellowish. Abdomen black, margins of segments gray. Fine hairs whitish and strong bristles on lateral posterior borders of each segment pale yellowish. Hypopygium greatly enlarged, much wider than 7th segment, black with black hairs. A tuft of long whitish hairs on under side. (Fig. 10).

Female. Similar, the mystax paler. The ovipositor slender, black, somewhat compressed, nearly as long as segments 5, 6, and 7 together.

Holotype, ♂, Santiago de Las Vegas June 18, 1921 (B. T. Barreto). Allotype ♀, Rio Almend, June 3, 1924 (F. Cervéra). Paratypes 5 ♂♂, Banes, March 21, 1926 (Dr. J. Bequaert); "Cuba" (M. C. Z.); Cuba, vic. of Habana, (T. Barbour); 4 ♀♀, "Cuba" (M. C. Z.).

Asilus ramsdeni new species.

Length 10 mm. Similar to the preceding, but the mystax is white, the legs all black, and the genitalia has a tuft of black, not white hairs, below.

Holotype, ♂, Tiguabos, Guantanamo, Cuba, Aug. 10, 1915 (Dr. Ramsden). Also an abdomenless specimen ($\frac{175}{96}$) in the Loew Collection, labelled "Cuba, Gundlach."

Asilus loewi new species.

Length 11 mm. Similar to *bullatus*, but the mystax is white, not golden, the femora and tibiæ (except tips which are black) are yellowish brown. The claspers are yellowish brown not black, are produced below, and lack the tuft of white pile.

Holotype, ♂, "Cuba, Poey," (96) Loew Coll. (M. C. Z.).

Erax Scopoli.

Typical Species: *E. rufibarbis* Macquart. North America.

Key to the Species.

1. Mystax pale 2
   Mystax at least partly black 3
2. Mystax straw yellow; hypopygium short and thick ..... *nigritarsis* Hine
   Mystax white; hypopygium long and narrow ..... *portoricensis* Hine
3. Large robust species 4
   Smaller species 5

4. Dark gray species; a tuft of black hair at base of ovipositor on under side.....*pilosulus* new species
   Lighter gray species; ovipositor without such a tuft; male with hypopygium much enlarged and with costa thickened and dilated beyond middle of wing.....*stylatus* Fabricius
5. Brownish species.....*brunnescens* new species
   Blackish or grayish species..... 6
6. Dark, slatey colored species, distinctly marked; hypopygium short, broad and shining black.....*rufitibia* Macquart
   Small greyish species, hypopygium elongate.....*cubensis* new species

In addition, the following species, occurung in the West Indies, although as yet unrecorded from Cuba may occur on this island.

nigrimystaceus Macq. 17 mm. Mystax black and yellow; costal border of wing slightly dilated, hypopygium, short, broad, black, with two minute emarginations at apex, one dorsal and one ventral. Related to *rufitibia* but differing in conformation of the hypopygium. *Dominica.*

fulvibarbis Macq. 25 mm. Rusty brown pollinose, mystax black above, yellow below, Hypopygium very long. Hind femora with 6 or 7 strong black bristles on outer side. *San Domingo.*

haloesus Walk. 18 mm. Mystax white with heavy black bristles, beard white, scutellum with white hairs on disc and slender black bristles on margin, costa not thickened, hypopygium elongate, reddish at tip. *Jamaica.*

Erax nigritarsis Hine.

Erax nigritarsis Hine, Annals Ent. Soc. Amer., Vol. XII, No. 2, p. 129, June, 1919.

Length 18 mm. Described by Hine as a gray pollinose species with mystax, beard, and hairs of the palpi all light colored. Femora black, tibiæ, except apex, yellow, tarsi intensely black. "Genitalia short, somewhat tumid from side view, narrowed from the middle towards apex when it is truncate."

The type is from Holguin, Cuba, Dec. 19, 1904, collected by H. S. Parish.

Erax portoricensis Hine.

Erax portoricensis Hine, Annals Ent. Soc. Amer., Vol. XII, No. 2, p. 128, June, 1919.

Length 21 mm. Distinguished by the long, black, slender hypopygium, white mystax, palpal hairs, and beard; and the costal border not dilated.

One male, Rio Seco, San Carlos Estate, Guantanamo, Cuba, July 4, 1915 (Dr. C. T. Ramsden).

Erax brunnescens new species.
(Plate I, Figs. 6 and 9).

Total length 15–21 mm. A light brown pollinose species.

Male. 1st two segments of antennæ black with black hairs, rest missing. Face very light yellow pollinose; mystax, beard, palpal and occipital hairs straw-colored. A few black bristles on occiput, vertex and upper part of mystax. Thorax yellowish-brown pollinose with a darker median stripe and lateral spots. Hairs and bristles on disk of thorax and scutellum black. Hairs of pleura light. Femora black with long, dense light yellow hairs; meso- and meta-femora with a few black spines in rows. Tibiæ reddish with light yellowish hairs and black spines, nearly black at the tip. Tarsal segments dark reddish, blackish towards tips. Wings with brownish tinge, the costal border not appreciably dilated. Halteres brownish. Abdomen light brownish pollinose, 6th and 7th segments silvery. Genitalia as in Fig. 13.

Female. Similar to male. Ovipositor black.

Holotype, ♂, Guantanamo (at light) May 10, 1917. (Dr. C. T. Ramsden); allotopotype, ♀, June 3, 1917, (Dr. C. T. Ramsden). 2 Paratopotypes ♂♂, May 14 and May 26, 1917 (Dr. C. T. Ramsden).

Erax stylatus Fabricius.
(Plate I, Figs. 1 and 4).

Asilus stylatus Fabricius, Syst. Ent. 795, (1775).
Asilus caudex Walker, List Dipt. Brit. Mus. II, 404, (1849).
Erax invarious Walker, Ins. Saundersiana, Dipt. I, 131, (1851).

Length, 20–28 mm. A large, common, grayish species, distinguished by the great black hypopygium and dilated costal border in the male and the long, bare ovipositor in the female. (Fig. 12). The femora are black, tibiæ, except tips reddish yellow. Mystax composed of black bristles and white hair.

Numerous specimens from Habana Province collected by S. C. Bruner and others. April–July. A female taken at Santiago de Las Vegas, May 24, '27 by S. C. Bruner was feeding on a male of the common "bee-killer" *Mallophora macquartii*, the prey considerably exceeding in bulk that of its captor—a remarkable instance of an Asilid which can overpower such a formidable insect as a honey-bee, falling prey to one of its relatives which at first sight would seem to be much weaker. So far as is known *Erax stylatus* does not feed on honey-bees, but confines its attacks to other diptera, small coleoptera, hemiptera, and lepidoptera and probably other small insects. Its longer legs and more rapid flight no doubt enable it to seize

and overcome the more bulky *Mallophora*. Dr. Bruner in a letter dated June 5, 1928, also reports the capture of a female *stylatus* Fabr. feeding on the Cicindellid, *Cicindella viridicollis* Dej.

Erax pilosulus new species.

Length 29 mm. A large gray species related to *stylatus*, but distinguished by the tuft of black pile at the base of the under side of the ovipositor.

Female. Head black; antennæ, occipital bristles, bristles of vertex, mystax and palpi all black. Face grayish brown pollinose. Beard composed of fine sordid white hairs. Thorax gray pollinose with intense black median line and lateral spots. Hairs and bristles black. Scutellum gray with black hairs and bristles. Femora, tips of tibia and tarsi intense black, rest of tibiæ reddish. Wings tinged with brown; stump vein absent. Abdomen black (greased) apparently the margins of the segments were originally gray. Ovipositor shining black, longer than segments 5, 6 and 7, base on under side with tuft of black hair. (Fig. 11).

Holotype, ♀, Sierra Maestra, Cuba, July 10–20, 1922. Coll. C. H. Ballou and S. C. Bruner 1070–1350 m. (Palma Mocha).

Erax rufitibia Macquart.

(Plate I, Fig. 18).

Erax rufitibia Macquart, Dipt. Exot. Suppl. 3, 27, 42, tab. 11, Fig. 11, (1848).
?Erax fortis Walker, List Dipt. Drit. Mus. VII, 623, (1855).

Length 18–21 mm. A rather blue-gray pollinose species with mystax and palpi mostly black haired, scutellum with black hair, tibiæ except tips reddish yellow, tarsi, deep red nearly black, femora black. Genitalia short, black, thick, 6 and 7th segments silvery. Costal border only very slightly dilated.

♂ ♂, Cuba, Gundlach, 15/44 Loew Coll. (M. C. Z.); "Cuba" vicinity of Habana (T. Barbour). ♀ ♀, Casa blanca, Habana, June 27, '26, (S. C. Bruner); Guantanamo, Cuba, June 20, 1915 (C. T. Ramsden).

Erax cubensis new species.

Length 15–17 mm. A small grayish species with elongate hypopygium which is reddish at tip and notched as in Fig. 14.

Male. Antennæ black, the 1st segment with whitish hairs beneath. Mystax composed of black and white hairs intermingled. Palpi with black hairs; beard white; occipital bristles black. Thorax brownish-gray pollinose, with median black line and three lateral spots on each side on mesonotum. Hairs and bristles of mesonotum black. Scutellum gray pollinose with white hairs and black marginal bristles. Femora

black with coppery reflections, tibiæ and tarsi pale brownish yellow. Tips of tibiæ blackish. Wings nearly hyaline with faint yellowish tint, costal margin not dilated. Stump vein shorter than its base. Abdomen black, the lateral and outer portion of the posterior margins of the segments white, segments 5, 6, and 7 silvery. Hypopygium longer than 5 + 6 + 7, slender, blackish with black hairs, the tip reddish. Fig. 13.

Female. Similar, but segments 5, 6, and 7 not silvery. Ovipositor black.

Holotype, ♂, Soledad, Cuba, June 21, 1925, J. C. Myers. in M. C. Z. Allotype, ♀, Soledad, April 6, 1926 (Dr. J. Bequaert); paratypes ♀ ♀, Soledad, May 22, 1925 (Geo. Salt); no. 251 Loew Coll. (M. C. Z.); Soledad, April 6, 1926 (Dr. J. Bequaert).

Proctacanthus Macquart.

Typical Species: *P. philadelphicus* Macquart. North America.

Only one species of this genus represented by a single specimen occurs in the collection.

Proctacanthus vittatus (Olivier).

Asilus vittatus Olivier, Encyclop. Methodique IV, 263, 4, (1789).
Proctacanthus rufiventris Macquart, Dipt. Exot. I, 2, 123, (1838).

A bright colored species with reddish-yellow legs and abdomen. The tarsi (except hind metatarsus which is reddish) and the base of the abdomen (1st segment and anterior half of second) are black. Mystax and pile of scutellum and along base of abdomen, golden. The palpi are yellow haired with one or two black bristles.

A small male (23 mm.) from Cayo Rosario, April 3, 1926, collected by F. Cervéra.

The synonymy of *P. rufiventris* I have discussed in a previous paper. Psyche, vol. XXV, no. 1, p. 14, 1928.

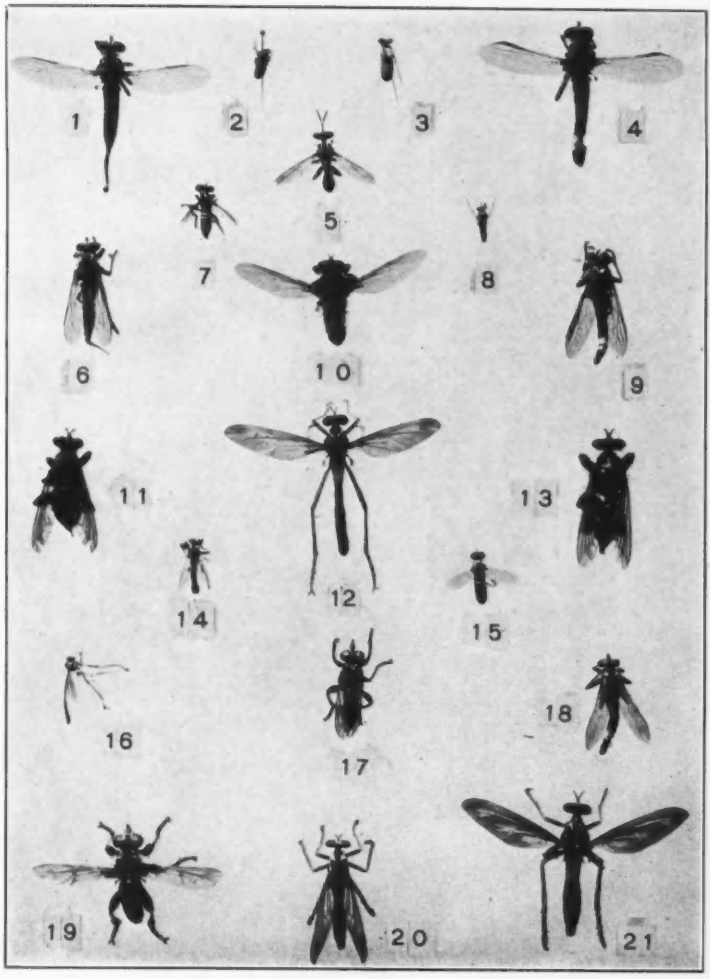
Eccritosia plinthopyga Wiedemann (Dipt. Exot. 184. 4. (*Asilus*) 1821) described from Cuba, I have not seen. The ♂ is described as 11 ½ lines in length (24 mm.), brownish, the base of the abdomen black and the apex testaceous, legs black. The beard and mystax are white, the scutellum fuscous, yellow-haired. The abdomen is described as having segments 1 and 2 all black with the sides white-haired, the 3rd black with the incisures testaceous, the 4th testaceous with a black triangular spot at the base; segments 5–7 all testaceous.

Eccritosia is distinguished from *Proctacanthus* by the abdomen being broad at the base, tapering sharply to the tip, and much shorter than the wings.

EXPLANATION OF PLATE I.

(Natural Size).

Fig. 1. *Erax stylatus* Fabricius, ♀.
Fig. 2. *Cerotainia laticeps* n. sp., ♀.
Fig. 3. *Atomosia pubescens* n. sp., ♂.
Fig. 4. *Erax stylatus* Fabricius, ♂.
Fig. 5. *Rhopalogaster bella* n. sp., ♀.
Fig. 6. *Erax brunnescens* n. sp., ♀.
Fig. 7. *Andrenosoma acunai* n. sp., ♂.
Fig. 8. *Atomosia parva* Bigot, ♂.
Fig. 9. *Erax brunnescens* n. sp., ♂.
Fig. 10. *Mallophora macquartii* Rondani, ♀.
Fig. 11. *Andrenosoma crassa* n. sp., ♀.
Fig. 12. *Plesiomma indecorum* Loew, ♂.
Fig. 13. *Andrenosoma crassa* n. sp., ♂.
Fig. 14. *Asilus bullatus* n. sp., ♂.
Fig. 15. *Atomosia similis* Bigot, ♂.
Fig. 16. *Leptogaster obscuripes* Loew, ♂.
Fig. 17. *Andrenosoma chalybea* Williston, ♂.
Fig. 18. *Erax rufitibia* Macquart, ♂.
Fig. 19. *Andrenosoma quadrimaculata*, n. sp., ♂.
Fig. 20. *Deromyia ternata* Loew, ♂.
Fig. 21. *Blepharepium annulatum* Bigot, ♂.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HOMOLOGIES OF TRACHEAL BRANCHES IN THE NYMPH OF ANAX JUNIUS BASED ON THEIR CORRELATION WITH THE MUSCLES THEY SUPPLY.

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Very few attempts have been made to homologize the tracheal branches in insects.

Chapman (3) homologized the trachael branches of the thorax in the winged insects. Kennedy (9) homologized the principal tracheal branches of the Zygopterous nymph as referred back to the simple system of a primitive segment. The forking of the tracheal branches was used largely by him in determining their homologies in the system. The writer has carried this a step farther in the Anisoptera by tracing the branches out to the somatic muscles which they supply.*

This correlation between the muscles and the tracheal branches supplying them, together with the forking of the branches, enables us to carry further their homologization if we believe that in the evolution of the insect the main tracheal branches at least, do not forsake the muscles to which they first ran.

Kennedy (9) and others, have shown that when the pleural folds on the thoracic segments of early instar naiads move up and later develop into wings, the tracheal branches supplying the folds accompany them. Another proof of the faithfulness of a branch to the organ which it supplies, is illustrated by the ganglionic tracheæ of the anterior abdominal segment. These branches accompany the ganglion of the first abdominal segment when it migrates into the thorax and joins the metathoacic ganglion.

Goodrich (7) has shown that nerves are faithful to the muscles in the limbs to which they run. In speaking of the jugular pelvic fins of the Codfish which have moved to their position in front of the pectorals, he says, "These limbs do not really lose their original connections, the displacements can be

*This work was done at the Ohio State University, 1926–1927, under the direction of Dr. C. H. Kennedy.

traced in ontogeny and the nerve supply in the adult infallibly betrays its course." "That a motor nerve is unable to forsake the muscle in connection with which it was originally developed to become attached to some other, seems to be in the highest degree probable, both on anatomical and physiological grounds." This does not necessarily prove that the tracheal branches have similar characteristics but it may indicate the possibility that such is the case.

Undoubtedly the best way to homologize the tracheal branches is to trace their evolution through a complete series of dissections starting with their first development in the embryo and continuing through each nymphal instar, as Nelson (12) has done with the honey bee, for example. However, this method was not attempted in the present work which is confined entirely to the abdomen of the *Anax junius* nymph.

The writer realizes that this prevents as accurate a homologization of tracheal branches as would be possible had the work in the thorax and head been completed, or had Nelson's method been followed; hence only those homologies which seem fairly obvious are discussed.

Variations and abnormalities in the smaller tracheal branches occur quite commonly and the readiness of the system to develop new branches makes the homologization of them impossible unless enough specimens are dissected to enable us to find the type most characteristic. Some of these abnormalities may give us valuable clues in homologizing the more specialized branches. Approximately fifty late instar nymphs were dissected in the present work.

NOMENCLATURE.

The nomenclature used for the tracheal branches in this paper is that worked out by Chapman (3) and Kennedy (9) with a few additions by the writer.

Whedon's (15) terminology for the muscles is used in most instances although some minor changes and additions have been made, and a few original names added for the muscles not figured by him. Attention will be called to these muscles as they are described.

No attempt was made to homologize the muscles of *Anax junius* with those of Orthopteroid insects as worked out by Ford (6). This was left for someone more familiar with the musculature of the various groups.

MUSCULATURE OF THE ABDOMEN.

(Figure 1).

Before attempting to homologize the tracheal branches in the abdomen of *Anax junius* and correlate them with the muscles a description of the abdominal musculature is necessary.

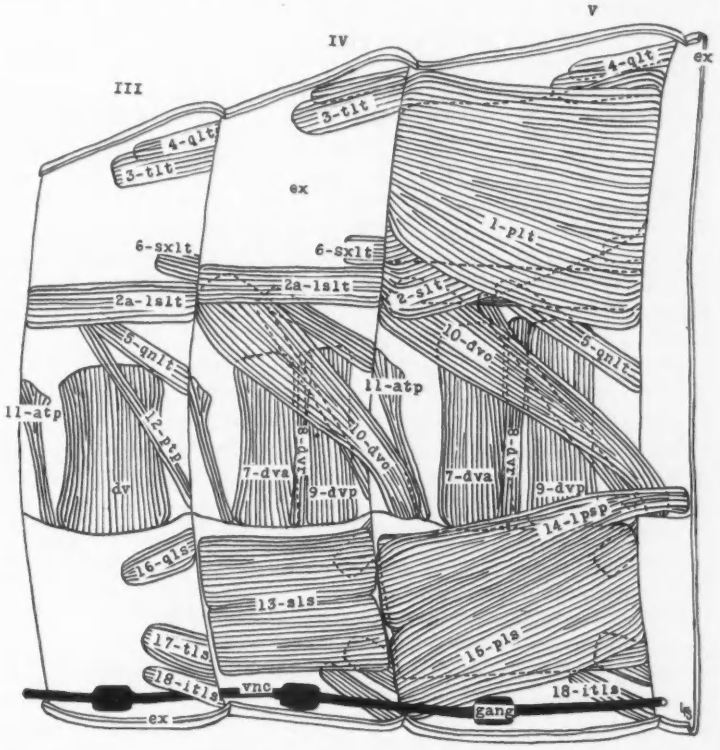

Fig. 1. Lateral view showing musculature in right half of abdominal segments three, four, and five of a male *Anax junius* nymph. Only the external layers of muscles are shown in segments III and IV. In segment V the musculature is complete. (See page 308 for explanation of terms.)

"The muscular system of the Aeshnid nymph is probably the most complex system among the various sub-families of the Odonata." (Whedon (15)).

It might be of interest to the reader to know that Miss Ford (6) found in the Odonata a marked difference between the musculature of nymphs and imagoes. She found that in the transition from nymph to adult it was the inner layer of muscles which disappeared leaving the shorter and smaller muscles of the outer layer.

Only the muscles of segments three, four, and five are shown in the Fig. 1 but these may be taken as representative of the other abdominal segments excepting one and ten. Some variation in point of insertion and size occurs among the muscles in the various segments as might be expected. In segments one and ten there is considerable specialization due to the junction with the thorax and the attachment of the caudal appendages respectively.

As Whedon (15) has already described and named the abdominal muscles in the nymph of *Anax junius* only a brief description will be given. The writer has considered as a separate muscle any group or layer of muscle fibers having its point of origin or insertion distinct from that of any other layer which might or might not be in contact with it.

The Tergal Musculature.—The Primary Longitudinal Tergal Muscles (1–plt) lie ventral to all the remaining tergal muscles and are narrowest at the anterior end. Their origin is on the anterior margin of the tergum and they diverge caudad to insert on the suture fold.

The Secondary Longitudinal Tergal Muscles (2–slt) lie dorsal to and in contact with the Primary Tergals but they converge caudad and are narrowest at the posterior end.

The Lateral Secondary Longitudinal Tergal Muscles (2a–lslt) (not figured by Whedon) have their origin external to the Secondary Tergals at their lateral anterior margin and insert upon the suture fold external to the posterior lateral margin of the Primary Tergals. This Lateral Secondary Tergal crosses the fibers of the other Tergal Longitudinal Muscles at an approximate angle of 30°. Whedon and others may have considered this a part of the Secondary Tergal. It is found in segments two to eight inclusive.

The remaining Tertiary (3–tlt), Quaternary (4–qlt), Quinary (5–qnlt), and Sextic (6–sxlt) Longitudinal Tergal Muscles have their origin on the face of the tergite and extend caudad to insert on the anterior margin of the suture fold. They vary in

length and thickness between themselves and in the various segments, being shortest and widest (excepting 6–sxlt) in the anterior segments and becoming longer as the segments become lengthened. The Sextic Longitudinal Tergal Muscle (6–sxlt) decreases in size toward the posterior end of the abdomen and in segment nine it inserts on a sharp pointed apodeme projecting forward from the anterior margin of the tenth segment.

The Sternal Musculature.—The Primary Longitudinal Sternal Muscles (15–pls) correspond to the Tergal Muscles of the same name except that they are much narrower. The attachment is the same and they occur in segments two to eight inclusive lying dorsal to the Secondary Longitudinal Sternals (13–sls).

These latter run parallel to the nerve cord, are of uniform width and are much thinner than the Primary Sternals. They also appear to be divided into two parts in the larger segments.

The Lateral Primary Longitudinal Sternal Muscles (14–lpsp) have their origin on the suture fold anterior to that of the Primary Longitudinal Sternals. In segments one to three inclusive they insert upon the anterior aspect of the suture fold of the following segment. In segments four to seven inclusive they narrow at the posterior end crossing laterally over the pleural suture to insert upon the inner anterior portion of the pleurite. In segment eight they are the same as in the first three segments. In segments nine and ten they become more specialized as do all the other muscles.

The Tertiary Longitudinal Sternal Muscles (17–tls), Inner Tertiary Longitudinal Sternal Muscles (18–itls), and Quartenary Longitudinal Sternal Muscles (16–qls), all have their origin on the floor of the sternum and insert on the anterior portion of the suture fold.

The Vertical and Oblique Muscles.—The Dorso-ventral Segmental Muscles (dv-) occur in all the segments except the tenth. In the first three they exist as single muscles with their origin covering a broad lateral line on the tergum. In segments one and nine these insert on the sternum, and in the intermediate segments on the inner margin of the pleurite. Beginning in segment four (Whedon says five) this muscle splits up into a Dorso-ventral Segmental Muscle, anterior part (7–dva), the Dorso-ventral Respiratory Muscle (8–dvr) (Whedon's dvs), and the Dorso-ventral Segmental Muscle, posterior part (9–dvp). These muscles reach the greatest size in segments five, six, and seven.

The development of the Dorso-ventral Respiratory in the region of the rectal gills is especially interesting. This muscle is more delicate than the other two and runs slightly oblique, having its point of origin higher on the tergum and its insertion farther forward on the pleurum. It is very heavily tracheated and seems to play the important part in the rhythmical abdominal respiratory movements. The other dorso-ventral muscles including the Dorso-ventral Oblique (10–dvo) no doubt are used chiefly to force the water from the abdomen in the sudden forceful expulsions characteristic of the nymph while swimming.

The Dorso-ventral Oblique Muscles (10–dvo) have their point of origin on the lateral anterior margin of the tergum, posterior and slightly lateral to the origin of the Lateral Secondary Tergals. Whedon speaks of these muscles as inserting on the anterior lateral corner of the pleurite and suture fold of the following segment in segments one to nine. The writer found this to be true in segments four to seven inclusive, but in segment eight the muscle was totally absent and in segments one, two, three, and nine it had its insertion on the anterior aspect of the suture fold, not reaching into the following segment.

The Anterior Tergo-pleural Segmental Muscle (11–atp) (not figured by Whedon) occurs in segments 1–9 and is very delicate. It has its origin in an oblique line on the anterior lateral face of the tergum and narrows ventrally to insert just anterior to the Dorso-ventrals.

The Posterior Tergo-pleural Segmental Muscle (12–ptp) (not figured by Whedon) occurs in segments 2-9 inclusive. It has its origin near that of the Quinary Longitudinal Tergal and posterior to that of the Dorso-ventral Oblique Muscle. The latter muscle when in place, covers the former at its point of intersection on the suture fold. They both pass to the inside of the Dorso-ventral.

METHOD OF CORRELATING THE TRACHEAL BRANCHES WITH THE PARTS SUPPLIED AIR.

Scott (13), Tillyard (14), and others have described the main tracheal trunks and their connections so we need not go into the details here.

By referring to Fig. 1 and Plate I the reader can connect the branches up to their respective muscles with the aid of the numbers.

Stippling within a branch was used to designate the part in contact with the exoskeleton. The extent of the tracheation of the hypodermal layer on the body wall was surprising. Evidently some respiration or interchange of gases takes place through the body wall for it does not seem as if the hypodermal cells would need so extensive a system in their secretion of the chitinous layers preceding ecdyses.

Many branches too small or not constant enough in their source or position, running to the exoskeleton as well as muscles, were not illustrated. Only the branches which the writer could depend on as being present in the majority of cases and were known always to run to the same muscle, were figured.

Wherever a number is found, does not necessarily mean that that particular muscle is the only one in contact with the trachea. The branch may cross over, under, or even run through the muscle and into another or it may lie between two muscles. All kinds of possibilities exist. Often times a branch lying on the body wall will have smaller branches starting in muscles running to it, while its larger end turns in and connects with a main branch. In other words the number indicates the muscle with which the branch seemed most closely associated at that particular point.

THE HYPOTHETICAL PRIMITIVE TRACHEAL SYSTEM AND APPARENT HOMOLOGIES IN *Anax junius*.

(Text Figure 2 and Plate I).

It is now generally believed that the primitive tracheal system was segmental, originating from spiracular pits in the body wall. Grassi (8) and several other writers have demonstrated this. Nelson (12) in his study of the honey bee shows that in the ontogony of the individual, the tracheal system first develops in this way as a segmental system and then later by fusion of its branches becomes a connected whole. The larger longitudinal trunks found in all the higher insects are thus proven to be secondary and not primary parts of the system.

The segmental unit as demonstrated in the embryo (Nelson p. 170) and by analysis in the Zygopterous nymph (Kennedy (9) consists of the following:

1. Spiracle.
2. Spiracular pit.
3. Spiracular trunk.....dorsad
4. Ganglionic trachea.....ventrad

Branches of the pit are:

5. Anterior spiracular connection.....cephalad
6. Leg trachea.....caudad

In the Odonata these have minor branches which are quite as definite as the main stems.

The above analysis differs slightly from that made by the writer. In *Anax junius* the leg trachea (lt ?) seems to have developed from the anterior spiracular connective (asc) and to turn cephalad instead of caudad. It will be necessary to go to the thorax or even to the embryology of the insect before this can be determined.

The writer has used a question mark in designating homologous parts about the origin of which there was considerable doubt. Tracheal branches or parts of branches figured in Text Fig. 2 and Pl. I, and considered homologous by the writer may be identified by the symbols drawn within them.

Because the segments figured in Plate I are probably the least specialized of any in the nymph they have been used as a starting point for constructing the hypothetical unit figured in Fig. 2. Anterior to them the system becomes modified by the proximity of the thorax. In the posterior end of the abdomen the development of rectal gills caused the tracheal branches to evolve to such an extent that it is almost impossible to homologize them. This shows up as far forward as segment six (Plate I).

Since the spiracle is the starting point for the development of the tracheal system in insect embryos it is the only logical point at which to start the hypothetical primitive unit.

From the Spiracle (sp) at the anterior margin of the segment there extends into the body wall of the primitive insect, a Spiracular Pit (spp). From the inner end of this pit there develops ventrad, the Ganglionic Trachea (gt) running to the ganglion of its segment. Turning forward from the ganglionic trachea is the Longitudinal Sternal Muscle Branch (lsg) supplying the sternal muscles at their posterior ends. Branching caudad from the ganglionic trachea is the Sternal Trachea (st) which extends into the next segment. Grassi (8) has shown that in Machilis the tip of this branch extends past the ganglionic trachea of the following segment. That these could easily fuse at this point to form the Sternal Trunk (st) in

Anax junius seems quite probable. By referring to *st* in segment VII Plate I we find that it has apparently fused with the tip of the longitudinal sternal muscle branch (lsg) of the ganglionic trachea in segment eight.

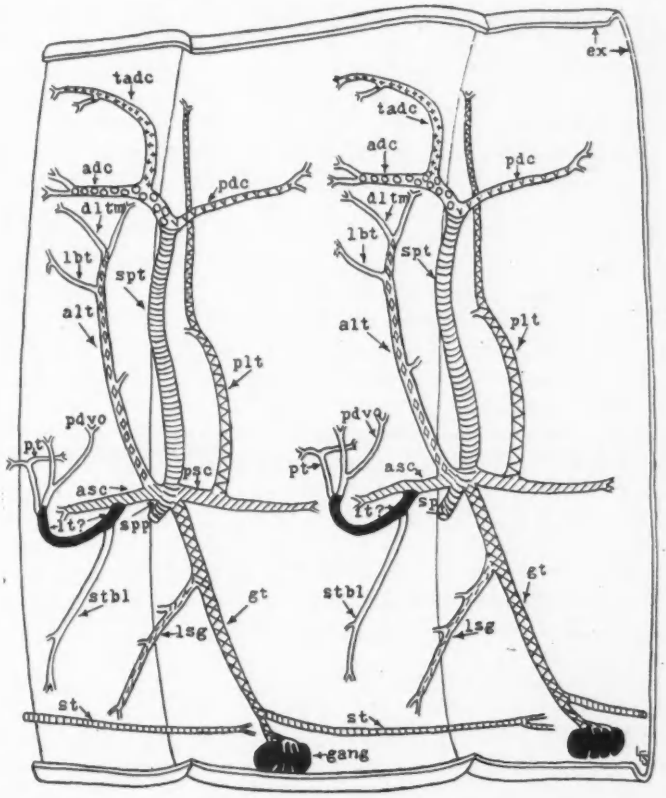

Fig. 2. Hypothetical, primitive segmental tracheal units. A series of such as these may have fused to form the present *Anax junius* tracheal system as shown in Plate I. (See page 308 for explanation of terms.)

From the bottom of the spiracular pit extends dorsad the Spiracular Trunk (spt). This branches and sends cephalad the Anterior Dorsal Connective (adc) from which extends

upwards to the heart and tergal muscles the so-called Tip of the Anterior Dorsal Connective (tadc). The caudal branch is the Posterior Dorsal Connective (pdc) which fuses with the anterior dorsal connective of the following segment to form the Dorsal Trunk (DT). Plate I.

It is interesting to note that in every segment except the eighth the ganglionic trachea (gt) still joins the ventral trunk (VT) at the junction of the spiracular pit, which would tend to indicate that it was the first and most important branch from the spiracular pit.

The spiracular trunk shifts a considerable distance from the pit connection in all the more specialized abdominal segments.

Extending cephalad from the base of the spiracular pit is the Anterior Spiracular Connective (asc). This gives off first, the Anterior Latero-tergal Trachea (alt) from which is sent the Lateral Branch to the tergum (lbt). Above this "alt" divides into a branch to the exo-skeleton and the Dorsal Branch to the longitudinal tergal muscles (dltm). The latter supplies the posterior and middle regions of the tergal muscles with smaller branches.

From the anterior spiracular connective is also sent the Leg Trachea (lt ?) about which the writer is in doubt. This turns out into the pleural fold and divides sending cephalad the Pleural Tracheæ (pt) which run to the Dorso-ventral muscles and sending caudad the Pleural Branch to the dorso-ventral oblique muscle (pdvo). The Sternal Branch of the leg (?) trachea (stbl) lies on the floor of the abdomen and its tips extend into the Tertiary and Inner Tertiary Sternal muscles.

The anterior spiracular connective fuses with the Posterior Spiracular Connective (psc) to form the Ventral Trunk (VT) Plate I. The posterior spiracular connective (psc) (leg trachea-Kennedy) sends a branch, the Posterior Latero-Tergal (plt) to the body wall in the anterior part of the tergum. From it short branches extend into the tergal muscles.

Reference to Plate I will show that the pleural trachea (pt) has shifted onto the ventral trunk.

REMARKS.

Many interesting problems presented themselves in the course of this work. For instance, in segment five a well-developed respiratory muscle branch (rmb) appears with the development of the Dorso-ventral Respiratory muscle. In size and development it is closely correlated with that of this muscle. In segments five and six this branch extends dorsally and laterally over the Dorso-ventral Oblique muscle and then turns down between it and the dorso-ventral muscles. In segment seven it does not loop around the Oblique at all but enters the space between this muscle and the dorso-ventral muscles from the lower side.

The branching of the trachea in the posterior part of segment seven is very complicated. The spiracular trunk which should arise in segment seven near the spiracular pit is missing.

It will probably be necessary to go back to the embryology of the species before some of these problems can be solved.

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EXPLANATION OF PLATE I.

Lateral view showing homologies of the somatic tracheal branches in the right half of abdominal segments three to seven in a male nymph of *Anax junius*. Numerals indicate the particular muscles with which the branches come in contact at that point. Homologous branches, or parts of branches, may be identified by the symbols drawn within them. Compare with Text Fig. 2.

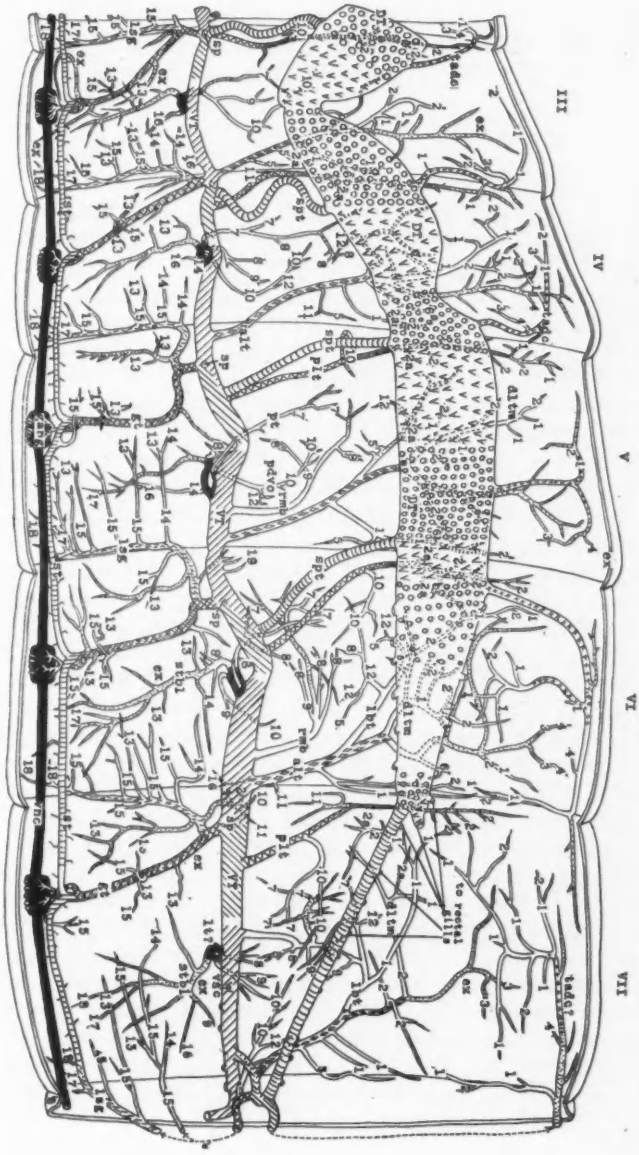
ABBREVIATIONS USED IN THE ILLUSTRATIONS.

Relating to Muscles.

1-plt—primary long. terg. muscle.
2-slt—secondary long. terg. muscle.
2a-lslt—lateral secondary long. terg. muscle.
3-tlt—tertiary long. terg. muscle.
4-qlt—quaternary long. terg. muscle.
5-qnlt—quinary long. terg. muscle.
6-sxlt—sextic long. terg. muscle.
7-dvs—dorso-vent. seg. muscles, ant. pt.
8-dvr—dorso-vent. respiratory muscle.
9-dvp—dorso-vent. seg. muscles, post. pt. dv, dorso-vent. seg. muscle. (in abdominal segs. one, two and three).
10-dvo—dorso-vent. oblique muscle.
11-atp—ant. tergo-pleur. seg. muscle.
12-ptp—post. tergo-pleur. seg. muscle, (oblique).
13-sls—secondary long. sternal muscle.
14-lpsp—lateral primary long. sterno-pleur. muscle.
15-pls—primary long. sternal muscle.
16-qls—quaternary long. sternal muscle.
17-tls—tertiary long. sternal muscle.
18-itls—inner tertiary long. sternal muscle.
19- —transverse muscle.

Relating to Tracheal Branches.

adc—anterior dorsal connective.
alt—anterior latero-terg. trachea.
asc—anterior spiracular connective.
dltm—dorsal branch to long. terg. muscles.
dt—dorsal trunk.
ex—exoskeleton.
gang—ganglion.
gt—ganglionic trachea.
lbt—lateral branch to tergum.
lsg—long. sternal muscle branch from ganglionic trachea.
lt?—*probable* leg trachea.
pdc—posterior dorsal connective.
pdvo—pleural branch to dvo muscle.
plt—posterior latero-tergal trachea.
psc—posterior spiracular connective.
pt—pleural trachea.
rmb—respiratory-muscle branch.
sp—spiracle.
spp—spiracular pit.
spt—spiracular trunk.
st—sternal trachea.
stbl—sternal branch of leg (?) trachea.
tadc—tip of anterior dorsal connective.
vnc—ventral nerve cord.
vsc—visceral trunk.
vt—ventral trachea.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IV
V
VI
VII
to rectal sinus

THE GENUS ECPANTHERIA (LEPIDOPTERA, ARCTIIDÆ).

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The present paper is primarily to call attention to certain structural characters in the genus Ecpantheria, which have escaped the attention of previous revisers.

There are three surveys of the genus. Oberthür, in the "Etudes Entomologiques," fascicle 6, figures all of the forms known to him, many of them new, but unfortunately without any descriptions, or any notes whatever on structures, and without any indication which forms might be of specific and which of varietal status. Hampson, in the "Catalogue of the Lepidoptera Phalænæ," vol. 3, p. 365, publishes a revision with some structural grouping, and with keys to the species. This is the only attempt to investigate structural characters, and unfortunately is surprisingly inaccurate. The antenna is made the primary character for subordinate grouping, but the antennæ are wrongly reported in a number of species, and the lobing of the hind wing, which is made the second character, is also incorrectly given in a couple. An attempt is made to reduce Oberthür's names, but some are sunk incorrectly, and others should perhaps be restored to varietal rank. In his "Supplement," vol. 2, pp. 445–455, the more recent species are added, but the errors of the original volume are not corrected. Finally Seitz, in the "Macrolepidoptera of the World," vol. 6, p. 315, goes over the genus, and figures most of the species. His grouping of the species is artificial, and structure is practically ignored.

The following analysis will bring out some of these characters, but is by no means the last word. In particular, the fore leg shows some variation, several species besides the new *E. chelifer*, showing some development of claws on the fore tibia, and the antenna showing considerable variation within the group without pectinations or definite serrations. Too many species are unknown to me to make the division at this time. The two series of species in which the second and fourth rows of

spots on the fore wing are reduced, are also undoubtedly related to each other, though one series has lobed and the other simple hind wings. It is not unlikely that some structure will yet be found to associate these.

The genus may be divided as follows:

I. Antenna plumose, fore wing rather short and bluntly rounded, *albicornis* only

II. Antenna shortly pectinate, the pectinations as long or twice as long as width of shaft; fore wing longer and more pointed. . *heterogena, muzina*, etc.

III. Antenna serrate. . . . . *deflorata*

IV. Antenna faintly serrate toward apex and fasciculate or simple.

A. Hind wing with anal lobe well-marked, normally long; fore wing with second and fourth rows of spots much smaller than first, third and fifth, and solid black. . . . . *læta* etc.

B. Hind wing with anal lobe very long, bearing a yellow hair-pencil on under side; spots of fore wing ocellate, and all the rows similar, *nigriplaga, orsa*, etc.

C. Hind wing moderately lobed, usually with long hair above, but no pencil below; spots of fore wing ocellate, and all rows similar, *detecta, burmeisteri, obsolescens*, etc.

D. Hind wing with a slight lobe, the concavity of 1st A being about ½ mm. deep; ocellate spots all similar and well marked, or markings wholly suffused with brown; fore tibia so far as examined, slender, considerably longer than metatarsus, with a small flat spine on its inner side; abdomen with a tawny middorsal stripe or spots, *indecisa*, etc.

E. Similar to group D, but fore tibia much shorter than metatarsus, with its inner claw more than half its length and very heavy, and with an additional outer spine. . . . . *chelifer*

F. Wings rounded, the hind wing not at all lobed, spots ocellate and equal, the hind wing also with ocellate spots; abdomen with a gray or black middorsal stripe or spots on an orange ground, *suffusa, confusa*, etc.

G. Wings rounded, second and fourth rows of spots small and solid black, as in group A, or else with fore wing almost wholly suffused with black; abdomen middorsally or wholly black. . *atra, andromela*, etc.

Key to Species, Male.

A. *Antenna plumose.*

1. Fore wing rounded, with regular ocellate spots, abdomen mainly blue (Cuba). . . . . ***albicornis**

AA. *Antennæ shortly pectinate—when the pectinations are only about as long as the segments, with the abdomen wholly without orange and hairy, or almost wholly orange.*

1. Abdomen blue, without orange, and overlaid with long white and gray hair; thorax with two or four longitudinal lines on collar, and loops on tegulæ.

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*† As in the preceding papers of this series, the asterisk indicates that specimens have been examined in the collections at Ithaca, and the dagger, that the species has been studied in other American collections: the U. S. National Museum, the American Museum of Natural History, and the Carnegie Museum at Pittsburgh.

2. Hair at base of abdomen white.
3. Collar with four fine parallel lines, tegulæ with long loops, the mesothorax with four fine lines.....(*mus*)
4. Ground of body and wings white.....†**m. mus**
4. Ground gray or buffy.....†**m. castronis**
3. Collar with a blue V, tegulæ each with a single blue bar, and disc of thorax with a pair; palpi and frons black, legs dominantly blue.....**kennedyi**
2. Hair at base of abdomen mainly gray; thorax as in *mus*, †**heterogena**

1. Abdomen with some orange, normally mainly orange; thorax with ocellate spots, if there are any at all.
2. Pectinations of male antennæ about twice as long as width of shaft; abdomen with transverse white bands, crossing the median line; wings immaculate, or with minute ocelli...***eridanus**
2. Pectinations about as long as width of shaft; abdomen with blue or white subdorsal spots, or largely blue; ocelli on fore wings usually well-marked, and of normal size.....***icasia**

AAA. *Antennæ markedly serrate, the serrations normally about half as long as width of shaft, and connected across ventrally; when somewhat longer, the abdomen blue, with orange middorsal spots, and concealed incisural lines.*

1. Thorax with solid blue spots, at least on the metathorax, and usually with two pairs on the disc also; a complete, black pleural line on the thorax under the wing; apical part of fore wing almost invariably transparent.
2. Pectinations as seen from above as long as width of shaft; ocellate spots on wings small and well-separated; not obviously blue, front more or less white below.....†**bolivar**
2. Pectinations half as long as width of shaft.
3. Markings of fore wing brilliant blue, heavy, the ocellate ones usually white-filled and well separated; extreme base of fore wing normally white, except for a blue spot on middle basal sclerite; ocellate spots small, the ones on collar usually covering less than half its area....(*scribonia*)
4. Fore wing with some ocellate spots, especially the postmedial ones in cells Cu_1 and Cu_2, or with apex translucent and spots obscure; abdomen with dorsal orange markings conspicuous.....***s. scribonia**
4. Spots solid blue, except perhaps the postmedial one on inner margin; abdomen practically solid blue above, **s. quitensis**
4. Fore wing with all spots ocellate and finely outlined.....†**s. columbina**
3. Markings black, slender, enclosing darker areas, the ocelli larger, and the pair on collar covering most of the collar; fore wing with confused basal markings before the usual antemedial series .....(*ocularia*)
4. Ocelli very large, flattened against the veins, and squarish, filled with pearl gray.....†**o. ocularia**
4. Ocelli moderate, a large proportion nearly circular, filled with cream color.....†**o. robusta**

AAAA. *Antennæ simple, sometimes slightly serrate toward apex and fasciculate in forms with rounded hind wings.*

B. *Fore wing with second and fourth rows of spots small and solid black, the alternate rows normally also black, or else suffused with black.*

C. *Anal angle of hind wing lobed, usually strongly.*

1. Mesothorax and scutellum each with a pair of black spots, which may be partially fused, but show at least some trace of a pale median line; fore wing with postmedial spot in cell M_3 located near its middle, and strongly oblique down and out.

2. Fore wing white, the dark spots on both thorax and fore wing small and well spaced..... **persola** (♂ not seen)
2. Fore wing with cream ground, reduced to a net of lines by the greatly extended black markings, the thorax also mainly black..... †**cotyora**

1. Mesothorax with a more or less completely separated pair of black spots, the scutellum with a single rounded spot; postmedial spot in cell M_2, when present, not strongly oblique, and located close beyond end of cell.
2. Thorax with small rounded black spots, covering less than half its surface; hind wing largely yellow, with short anal lobes; veins of fore wing not yellow..... (*leucarctioides*
3. Ground pure white..... †**l. leucarctioides**
3. Ground of both wings cream..... ab. **tenella**
2. Thorax with large bar-like spots on tegulæ and disc; veins of fore wing yellow; hind wing with moderate to large lobe, transparent yellow, with more or less fuscous suffusion.
3. Lobe half as long as width of hind wing, broadly tipped with black; hind wing typically much shaded with fuscous.. †**læta**
3. Lobe a third to a quarter as long as width of hind wing, with a small black dot at its tip..... (*præclara*)
4. Ground of fore wing pure white..... †**p. præclara**
4. Ground pale yellow..... †**p. theophila**
2. Fore wing without yellow veins, hind wing mostly white, black markings of thorax extensive..... †**magdalenæ**
3. Antemedial and postmedial series of dots somewhat interrupted..... †**typical**
3. Ante- and postmedial series of dots complete and strong, v. **steinbachi**

1. Mesothorax and scutellum each with a single middorsal spot, or thorax with a continuous middorsal band.
2. Ground of fore wing yellowish, much less extensive than the black markings..... (*ochreator*)
3. Transverse bands of the fore wing centered with bright yellow lines, the veins deep yellow..... †**o. euripides**
3. Fore wing with faintly yellower veins only..... †**o. ochreator**
2. Ground of both wings white, the fore wing with ground more extensive than markings..... †**brasiliensis**

CC. *Hind wing rounded.*

1. Terminal half of abdomen yellow with black dorsal dots; fore wing mostly black, hind wing blackish..... †**andromela**
1. Abdomen black to apex, with the usual yellow side-stripes.... (*atra*)
2. Hind wing mainly blackish.
3. Forewing mostly black..... †**a. atra**[1] (*eminens*)
3. Fore wing about half black..... †**a. extrema** (*chilensis*)
2. Hind wing mainly white.
3. Markings with distinctly darker edging, the second and fourth rows only a little smaller than the third..... †**obtecta**
3. Markings of perfectly even brown-black, the second and fourth rows of small spots, the third on the contrary forming a solid black band..... †**a. amulaensis**

BB. *Fore wing with at least the more basal spots ocellate (or fused into dark-bordered bands), the second and fourth rows like the others.*

C. *Hind wing with a strong anal lobe, with a groove containing a hair-pencil on the under side.*

1. Abdomen pink, with transverse black stripes..... †**nigriplaga**
1. Abdomen orange and black, without pink..... ***orsa**

[1]The very brief description of *amula* Strand (*amulaensis* ab. of Hampson) gives no characters to distinguish it from *atra*.

CC. *Hind wing with a moderate anal lobe; with a mass of long hair above, sometimes making a pencil, but no groove or pencil below.*

1. Ground of abdomen scarlet, with blue-black subdorsal spots; black pleural stripe of thorax strong on mesothorax of specimens seen, but not continued on metathorax.....†**burmeisteri**
1. Ground of abdomen orange or blue.
2. Abdomen with the middorsal region dark (blue or gray) but with addorsal orange spots or bands; pleural stripe continuous.....(*detecta*)
3. Abdomen with orange stripes at least as broad as the gray ones, the middorsal stripe sharply defined.....***d. dorsata**
3. Abdomen black, with small subdorsal orange stripes, extending about three segments.
4. Smaller, subterminal ocelli of fore wing well-marked, **d. detecta**
4. Larger, a vague subterminal gray shade.....**d. dognini**
3. Abdomen with two pairs of small orange spots only.**d. detectiva**
2. Abdomen with orange dorsal marking when present best developed at the middorsal line.
3. Fore wing with continuous, dark-outlined gray bands, not at all interrupted by the veins (rather obscure on account of the translucence of the wings); abdomen almost wholly blue.....†**gaujoni**
3. Fore wing with ocellate spots between the veins.
4. Abdomen with orange only on sides, none whatever dorsally; fore wing with spots olive-filled; thorax with black pleural stripe.....†**jaguarina**
4. Abdomen with some orange middorsally at least, thorax with black stripe weaker or absent; spots of fore wing rarely olive-filled.
5. Large (70 mm.), robust, apex transparent, abdomen normally striped transversely with gray, rarely blue.....†**peruvensis**
5. Smaller; apical part of fore wing with pattern; abdomen always powdery gray and orange, never blue.
6. Expanse about 55 mm. Hind wing typically with a double spot at end of cell and a subterminal spot near anal angle (cells Cu_1 and Cu_2).....†**ganglio**
6. Smaller, hind wing at most with a vague shade along fold.
7. Pattern on abdomen dorsally irregular.
8. Ground buffy, the shade on fold heavy, †**obsolescens**
8. Ground deep buff, some of the ocelli contrastingly paler.....**testacea**
8. Ground practically white, the hind wing with a slight gray shade at anal angle only.....†**cretacea**
7. Abdomen with a continuous middorsal orange stripe with no tendency to be broken into separate spots or transverse bands.....†**kinkelini**

CCC. *Anal lobe of hind wing slight (½ mm. deep) or none.*

1. Abdomen with middorsal region of the darker (gray) color, flanked by tawny or orange.
2. Ground white, with contrasting brown spots.....**oslari**
2. Ground not white, when very pale with the filling of the ocelli hardly darker.

3. Ground of fore wing cream to light buff; dorsum of abdomen with small black spots.....†**confusa**
3. Ground of fore wing gray; abdomen with transverse gray bars.....†**suffusa**

1. Abdomen with a series of middorsal orange spots, the addorsal region dark.
2. Ground pure white.
3. Spots very large and partly confluent, leaving narrow streaks of the white ground.....**melanoleuca**
3. Spots small and wholly separated; fore tibia solid fuscous, †**obtecta**
2. Ground gray or brown; fore tibia with a black pattern.
3. Fore tibia short, with a claw more than half as long as itself.....***chelifer**
3. Fore tibia longer than metatarsus, with a weak claw.
4. Ocellate spots slightly grayer than ground, and defined by white outlines only.....†**albiscripta**
4. Ocelli dark, and outlined with dark as well as pale, ***indecisa**

1. Dorsum of abdomen and fore wings brown, without obvious markings.....**anomala**

Key to Species, Female.

1. Fore wing with second and fourth series of spots solid black, and much smaller than first, third and fifth..... 2
1. Fore wing with numerous black spots, not arranged in series of unequal size..... 5
1. Fore wing otherwise marked, almost always with ocellate spots..... 6
2. Hind wing mainly black or dark gray..... 3
2. Hind wing ochre yellow with black spots.....†**ochreator**[2]
2. Hind wing mainly white..... 4
3. Thorax with paired spots, sometimes partly fused, but showing traces of the pale dividing line, on both mesothorax and scutellum; postmedial spot in cell M_2 of fore wing half-way out to outer margin and strongly oblique.....†**cotyora**
3. Mesothorax with paired spots, scutellum with a single rounded spot; postmedial bar in cell M_2 close beyond end of cell, †**laeta, leucarctioides, magdalenae, praeclara**[3]
3. Thorax with both spots unpaired, or with a longitudinal band; postmedial spot as in the preceding category.....†**brasiliensis**
4. Third (median) series of spots in fore wing represented by a broad and solid black band.....†**amulaensis**
4. Third series of spots represented by a band cut by contrasting yellow veins.....†**andromela**
4. Third series of spots separated by white veins; hind wing with spots small, or else suffused with fuscous.....†**extrema**
5. Hind wing and abdomen yellow.....†**persola**
5. Hind wing white, abdomen dorsally blue.....**scribonia quitensis**
6. Abdomen wholly blue, white and gray, without orange even on sides..... 7
6. Abdomen at least with orange lateral stripes..... 9
7. Base of abdomen with mostly smoky hair; larger and coarser.....†**heterogena**
7. Hair at base of abdomen mainly white; smaller (*mus*)..... 8
8. Ground practically white, with white-filled ocelli; hind wing mainly white.....†**m. mus**

[2]The female of *euripides* is unknown; it is likely to be separable in the same way as the male.

[3]There are females in the U. S. National Museum associated with these various male forms, but I am unable to distinguish them.

8. Fore wing cream or buff, the ocelli darker-filled; hind wing with fuscous area at least entering cell, the wing often mainly fuscous.....†**m. castronis**
9. Abdomen with middorsum solid blackish, flanked by addorsal orange markings.....10
9. Abdomen with dorsal orange markings, when present at all, best developed on the middorsal line, frequently with middorsal segmental spots.....11
10. Ground of fore wing light buff, dorsal spots of abdomen very small..†**confusa**
10. Ground of fore wing gray; dorsal spots conspicuous, frequently developed as transverse bars.....***suffusa**[4]
11. Ground of fore wing gray or smoky; abdomen mainly gray or blue.....12
11. Ground of fore wing white, frequently tinted with buff or pinkish, somewhat darker in some specimens of ***nigriplaga***, which have the abdomen transversely striped with pink and black.....14
12. Abdomen wholly blue above, with lateral orange stripes, only; fore wing banded, not ocellate.....†**gaujoni**
12. Abdomen spotted dorsally with orange.....13
13. Spots of fore wing outlined in black and white; fore tibia banded.....***indecisa**
13. Spots of fore wing outlined in black and bright yellow; fore tibia plain blackish.....†**obtecta** (*flavomaculata*)
13. Spots of fore wing outlined in white only.....**albiscripta** (supposition)
14. Abdomen pink or scarlet.....15
14. Abdomen with more or less orange, not red.....16
15. Abdomen with transverse dorsal stripes; ocelli of fore wing heavily ringed with black, and frequently dark- or pale-filled.....†**nigriplaga**
15. Abdomen with subdorsal spots; ocelli filled with darker gray and frequently large or even confluent.....†**burmeisteri**
16. Abdomen orange, with the subdorsal markings largely white, normally outlined in blue.....17
16. Abdomen dominantly blue, or subdorsally spotted with blue.....18
17. Abdomen with transverse dorsal white stripes crossing the middle line; fore wing immaculate or with a few small ocelli.....†**eridanus**
17. Abdomen with subdorsal white bars, the fore wing frequently with a regular pattern of ocelli.....***icasia**[5]
18. Abdomen with a continuous orange dorsal stripe on middle segments; body more or less gray.....**aramis** (? ♀ *kinkelini*)
18. Abdomen otherwise marked, frequently with a series of middorsal orange spots.....19
19. Hind wing and filling of ocelli of fore wing white.....20
19. Hind wing more or less shaded with fuscous, the centers of the ocelli of fore wing markedly darkened.....25
20. A black line on side of thorax, extending back from the eye below the base of the wings.....21
20. No such stripe, the thorax at most with a few blackish hairs behind the eye.....22
21. Abdomen orange with blue spots.....**orsa decora**
21. Abdomen mainly blue.....***scribonia**, †**i. mexicana**
22. Hind wing with numerous gray-filled and sometimes somewhat suffused, ocelli (Cuba).....***albicornis**
22. Hind wing with slight markings or none (Mainland).....23
23. Abdomen blue with small orange spots.....†**obsolescens**
23. Abdomen largely orange, with dark transverse bands.....24

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[4]The female of *detecta*, which is unknown to me, will presumably run here; it will probably be larger, with more visibly lobed hind wings. The female credited to *dognini* appears to me very improbable, as, so far as we know, females in this genus always have the black markings less extensive than the males. It may possibly be the true female of *jaguarina*.

[5]This character will occasionally fail, but I know of no better one; the antennal difference in the male shows that these are really distinct species.

24. Fore wing, and especially filling of ocelli, more or less buff.....**testacea**
24. Fore wing nearly white; smaller.....†**cretacea**
25. Ocelli very large and squarish, being more or less flattened against the veins, or even partly fusing.....***ocularia**
25. Ocelli normal, usually well separated[6].....26
26. Abdomen wholly blackish, even the incisural folds....**jaguarina** (supposition)
26. Abdomen with at least middorsal orange spots.....***orsa**

DISCUSSION.

It will be noted that the most serious divergences from Hampson's arrangement are due to the recognition of pectinate antennæ or of the lobe and pencil of the hind wing in several forms where he did not note any secondary sexual characters. The groupings into races are tentative, but I think correct in the case of the two protean species *orsa* and *icasia*. I have placed several of Oberthür's names tentatively, since he gives no hint of the structural characters. The stripe on the side of the thorax, from the eye to the base of the abdomen, just below the articulation of the wing, seems to be a good character, but breaks down in the case of *E. icasia*, where it may be present or absent in otherwise similar specimens from the same region. Generally it seems constant for species, and even groups of species.

E. albicornis Grote. As I noted some time ago (Bull. Am. Mus. Nat. Hist. xxxvii, 340), this species stands in contrast to all the rest of the genus in the broadly pectinate male antennæ. The appearance is also unique, as shown well by Grote's original figure, (Proc. Ent. Soc. Phil. 1865, pl. 4, Fig. 4), and the species may be one of the numerous Antillean relict-forms. It is in the National Museum, the American Museum, and at Cornell, in all three cases from the Schaus collection. The species in spite of its different appearance shows most of the characters of *icasia* and *eridanus*, and I am not sure the key characters will always work for the female. In all three the face is white below, with or without a black bar.

E. eridanus Cr. Cramer's figure is of a female, in spite of Seitz's note that "only males seem to be known hitherto." Oberthür figures a male from Colombia under this name, and both Hampson and Seitz seem to have described merely from

[6]Light specimens of *orsa* may lose the gray on the hind wing, and then look much like *icasia*, but apparently in that case they always have light faces, and plainly fuscous-centered thoracic markings.

Oberthür's specimen, which I take to be an immaculate specimen of *icasia muzina*, especially as we have a similar immaculate specimen of *i. icasia* from Porto Rico. On the other hand there is a species in Guiana (Cramer's type locality) which characteristically has the white stripes across the abdomen, and is undoubtedly Cramer's species. As noted in the synopses it has significantly broader antennæ than any of the forms of *icasia*. The National Museum has a maculate specimen, and it shows minute ocelli, as in Hubner's figure of *eridane*. The name eridane is obviously only a variant spelling of eridanus, and has therefore no standing.

E. kennedyi Roth. Unknown to me. The male should be easily recognized by the characters given by Hampson and repeated in my key. The species of this group are so strongly dimorphic sexually that there is no guarantee that the same characters will appear in the female.

All the species of this group are distinguished by the fact that the collar has stripes its whole height, instead of the ocelli or loops of the rest of the genus. The complete absence of orange or red on the body also seems characteristic.

E. mus Obt. I can recognize only two races of this species in the material I have seen: typical *mus* (in the National Museum from Bolivia) and *m. castronis* Strand (*brasiliensis* Roth., not Obt.), from Castro, Paraná, Brazil. If the gray abdominal hair is of specific value, *heterogena* will be a distinct species, and is distinguishable in both sexes; but it is hardly more distinct from *castronis* than *castronis* is from typical *mus*. I am inclined to think the antennæ are a little broader in *heterogena*.

E. heterogena Obt. In the typical form the front is white, in *pellucida* black, but the character appears only of aberrational value in most species of this genus. *Contexta* is, I judge, the normal female.

E. icasia Cr. This name represents the Antillean form of a variable species or series of representative species scattered over a large part of Central and South America. There is a great deal of variation in most details of pattern, and even some in the wing-form of the female, but the whole series seems to intergrade completely, and even in the typical localities of the various forms there is usually a wide range of variation. The

most distinct form is *icasia* itself. If we consider only typical specimens of the various local forms, they may perhaps be separated as follows, but the exceptions are about as common as the normal forms, and in Venezuela there appears to be a complete blending of all.

(a). **E. i. icasia.** Collar white, without ocellate markings, which are usually conspicuous on the rest of the thorax and fore wing. Abdomen bright orange, the subdorsal spots normally small and well-contrasted, typically blue-black, but sometimes largely white, even in the male; in the female as usual, white. Markings tend to be light but clean-cut. Female with anal lobe well marked and pointed, the wings frequently immaculate or nearly so. Antilles.

Guadulpensis is an aberration with a broken dark postmedial line on the hind wing.

(b). **E. i. trinitatis** Roth. Pale, tending to become immaculate, the ocelli usually fine, but distinct, and present on collar as well as thorax and wings; the abdominal spots typically with some white in male, and wholly white in female; female wings long, and anal lobe of hind wing pointed, as in *i. icasia*. This is the normal mainland form of the species, and I cannot subdivide it, though Mexican and Peruvian specimens each seem to have a slightly different appearance. There is complete intergradation between this form and *muzina*, but as the latter seems locally constant in part of Colombia, and has a distinctly different wing-form in the female at least, I am holding it as a good race. I found the larvæ of *trinitatis* somewhat abundant in Lima, Peru, where they do some damage to shade-trees in the city; they are not noticeably different from *scribonia* save in their smaller size.

Oberthür has described *abscondens*, *garzoni*, *yukatanensis* and *xanthonota* in this group. *Yukatanensis* is transitional to *mexicana*, the other three names fairly represent the range of normal variation in the female. Of the other female names, *abscondens* has a complete series of small submarginal ocelli on the hind wing, while in *garzoni* and *xanthonota* the ocelli are large, and there is also some postmedial dark shading toward the inner margin.

Albicollis from Brazil, distinguished by the absence of ocelli on the collar, as in typical *icasia*, combined with the

white abdominal spots of *trinitatis*, may be a distinct form, but it is unknown to me, and a single specimen is not enough to found a race on in such a variable species as this.

(c). **E. i. muzina** Obt. Markings complete and well contrasted, the hind wings of the female with the anal angle broadly rounded, and less prominent than in the other forms on account of the generally broader wings. In the original figure of the male, and the dwarf figured as *thimei* Obt., there are no rings on the collar, but they are generally present; *depauperata* Obt. is the female of this form, and represents a specimen with almost wholly white hind wings.

(d). **E. i. mexicana** Obt. This appears to be a partially racial form in Mexico and Central America. In it the abdomen is mostly blue, but at least with orange mid-dorsal segmental spots. The National Museum has a complete series of intergrades from it through forms with large triangular blue spots on orange (*yukatanensis*) to specimens not unlike normal *trinitatis*. The blue body strongly suggests a light phase of *scribonia*, but the male structure is quite distinct. Still it is not unlikely that Mexican specimens of *scribonia* may be mixed with this in some collections.

E. bolivar Obt. This species seems like a connecting link between *scribonia* and *icasia*. On final analysis the only superficial character that seems to separate it from *icasia* (form *mexicana*) is the presence of solid blue spots instead of dull black ocelli on the back of the thorax. The antennæ are almost as wide as in *icasia*, but the appearance really suggests a nearer relationship to *scribonia*. I have not recognized the female, which will presumably have ocelli on the metathorax, and be hardly distinguishable from *mexicana*.

E. scribonia Stoll. The "Great Leopard Moth" of North America has been known for a century under this name. Hampson thought he recognized in it Fabricius' *deflorata*, but his other identifications in the genus are so often wrong that it seems safer to go back to the old name, especially as Fabricius plainly speaks of a moth with *four* black spots on the thorax instead of the twelve spots or ocelli of *scribonia*. Also Fabricius speaks of the wings as merely spotted, while it is very rare to find a specimen of *scribonia* without some conspicuous ocelli. It would not be impossible that Fabricius had *Hy-*

phantria cunea! The North American form of this species is well known. Specimens from south of the U. S. line seem very scarce, though I have seen a single specimen in the American Museum which appears to represent v. *columbina* Obt.; it comes from Paraguay. So far as I know, all the forms have the bright blue front and fore coxæ, without the variation to barred and gray-marked forms usual in the genus. The two racial forms known from South America are opposite extremes, *quitensis* having the ocelli all replaced by solid blue spots, while in *columbina* they are as slender as in other species of the genus. Oberthür's aberration *confluens* has the second and third rows of ocelli fused; it belongs to typical *scribonia* and not to *quitensis* as Hampson states. *Denudata* is merely based on specimens with the apex of the *fore* wing transparent; it is really the normal male.

E. ocularia F. What commonly goes as *ocularia* Fabricius is a close relative and in a way a representative of *scribonia* in South America. I see no real difference in the antenna, and such characters as the front and coxæ are also the same, but the large dark-filled ocelli give it a very different appearance. *Robusta*, to judge by the types in the National Museum, is merely a slight local form, with the difference given in the key. I am not at all sure of the female characters in this series; and there may exist specimens of *peruvensis* with blue abdomen which would be practically identical with *ocularia*. The one female *peruvensis* in the National Museum has a gray abdomen like the more usual males. There also seems to exist at least one more species with simple antennæ and almost the same pattern, besides *jaguarina*, which may be distinguished in the male, and presumably the female, by the complete lack of dorsal orange even in the infolded incisures.

Next follow a group of very distinct species in which the antenna is simple, but the hind wing has a strong lobe, and the markings are wholly of black spots, without the usual ocelli. In all cases the second and fourth rows of spots are distinctly reduced in size, a character which reappears in some species of the closely related genus *Turuptiana;* but the difference in size is small in *E. persola*. There are perhaps fewer species than I have recognized, but the presence of single or paired spots on the thorax, which I have used in the key, appears to be an important character. Some forms of *læta* would also appear

identical with *præclara*, were it not for the distinct difference in the anal lobe. In fact I am completely unable to separate the females of these two species. The species of this group lack the hair-pencil on the under side, but have only a little stiff scaling, while in *orsa*, *decora* and *nigriplaga* the pencil is conspicuous. The group is an ancient one, apparently, and is one of those curious types, like *Clothilda*, which are confined to Central America and the Antilles, without making the connection through northern South America. Presumably the group is older than the present break (of sea and desert) between Cuba and Yucatan.

E. persola Msch. I have not seen the male; to judge by the female the species is unique in having three spots on the scutellum, an odd one besides the two it shares with *cotyora*. The position of the postmedial line opposite the cell shows that the connection with *cotyora* is fairly close.

E. nigriplaga Wlk. Another of the very curious series of species known only from Jamaica. It is obviously an island representative of *orsa* (*cunigunda*) of the mainland, but is very distinct in the red color of the abdomen, and the lobing of the hind wing is even stronger. On the other hand, *decora*, from the other Greater Antilles, has the anal lobe rather small, and if it were not for the well-marked hair-pencil, might not be recognized as belonging here.

E. orsa Cr. I think the lobed hind wing and general pattern leave no doubt that this is the same species that Stoll later named *cunigunda*. In Cramer's figure, which is much cruder than most of his, the fore wings have a complete pattern of ocelli. This is a rare character, but I have seen such specimens; more often the apex is more or less transparent (ab. *cunigunda* Stoll). Hampson overlooked the yellow hair-pencil on the under side of the hind wing, which is distinctive of this species and *nigriplaga* (and *decora* if distinct); and has the synonymy completely confused. Considering this character, and including the females which seem to be associated here, I believe the series includes: *orsa* Cr., *cunigunda* Stoll, *cayennensis* Obt., *decipiens* Obt., *bari* Obt., *dubiosa* Obt., *alpha* Obt., (with *orbiculata* in part), *perplexa* Schs., *abdominalis* Wlk., *proxima* Obt. and *annexa* Obt. (with the rest of *orbiculata* Obt.). These names were described from a wide range

of localities, and some of them represent more or less tangible local forms, but they intergrade as completely and are as unstable in a given locality as the forms of *E. icasia*. The following names belong to other species without the lobe and hair-pencil: *detecta* and *detectiva* Obt., *aramis* Obt., *ganglio* Obt. *Ganglio* shows a striking superficial resemblance to females of this species, but I cannot imagine how the others came to be put in the synonymy.

(a). **E. o. decora** Wlk. (*cyaneicornis* Grt., *haitensis* Obt.). A very distinct form, or possibly a representative species, isolated in the Greater Antilles. It can be distinguished by the fact that the dark markings at the end of the cell (parts of two or three confused ocelli) are shining metallic blue, contrasting with the clear black of the rest of the markings. Body orange with black spots in male, reduced to dots in the female. Face white; bar on thorax below base of wing varible; hind wing with dark shading in fold only in male, with ocellate spots in female.

(b). **E. o. orsa** Cramer. Typically with a complete pattern of black ocelli, more often (var. *cunigunda* Stoll.) with the apical half of the fore wing transparent in the male. Cayenne to Venezuela.

(c). **E. o. alpha** Obt. Hardly a tangible local form, but generally larger, the female tending to have a pale hind wing. Mexico.

(d). **E. o. perplexa** Schs. A gray postmedial band on hind wing, distinct at least on inner margin. This may turn out to be an aberration rather than a race, but seems locally constant. Costa Rica.

(e). **E. o. abdominalis** Wlk. I question if this can be held as a race, though in series there appears to be a little difference in appearance. I believe the difference given by Hampson between alpha and abdominalis is purely imaginary, perhaps due to a different setting of the hind wing. If the hind wing is not carefully spread the anal region remains folded and the hair-pencil will be completely concealed. Brazil.

Next follow a series of species which agree in not having any very distinctive sexual characters either of the wing or the antenna. They are perhaps not a homogeneous group, yet are somewhat connected by a chain of resemblances. All

have a moderate anal lobe in the male, less conspicuous in the female. The band on the side of the thorax is more stable in this group than the preceding, and seems always to be the same in a single species, and even in groups of closely related species.

E. detecta Obt. As this species I group all the forms in which there is a gray middorsal region, flanked by addorsal orange spots or bands; the amount of orange varies markedly, and I think locally, from the broad bands of the new form described below to the minute dots of var. *detectiva*. I put *dognini* here with some hesitation, as I have not seen it; the male shows the characteristic addorsal orange, but it is figured as larger than typical dectecta, and the suffused gray subterminal band, if not a mere individual aberration, is unique in the series. The female, as figured by Hampson, shows neither the orange spots nor the subterminal band, and, as far as I can see is the proper female to go with *jaguarina* Schs., which also has the plain blue dorsum and olive-tinted ocelli. I should recognize four forms, which appear to be racial.

(a). **d. detecta** Obt. Fore wing with ocellate spots larger than the spaces between them, and gray-filled. Hind wing pure white, without obvious markings. Abdomen gray above, with two short orange stripes, setting off a median longitudinal gray stripe, which is cut only by the orange incisures (usually concealed by the shrinking of the abdomen). Para, Amazons.

(b). **d. detectiva** Obt. Paler (faded ?), the ocelli relatively smaller; hind wing with a gray anal spot, the orange on the abdomen reduced to two pair of small spots. Locality not stated.

(c). **d. dognini** Roth. Larger, the ground more or less yellowish, the ocelli showing the buffy tint of *detectiva*, but more nearly the pattern of *detecta*; the abdomen as in typical *detecta*. Southern Brazil.

(d). **d. dorsata** new race.

Fore wing as in the typical form, with ocelli large and nearly in contact, and markedly gray-tinted; dorsum of abdomen broadly orange, with a relatively narrow gray middorsal band. In the type the whole dorsum is orange, with dorsal and lateral gray stripes; in the paratypes the gray is more extensive, and the dorsal stripe is irregularly widened.

Urucum, above Corumbá, Matto Grosso, Brazil, Dec. 23, 1919, Bradley and Harris.

E. jaguarina Schs. This species is perhaps the most generalized of the group, except for an undescribed species, which differs from it mainly in having preserved the orange pattern of the abdomen. It is instantly recognizable in having no dorsal orange whatever, and almost as definitely in the light olivaceous buff tint of the filling of the ocelli, approaching *robusta* in appearance. The thorax has the lateral stripe, like the *scribonia* group, etc., but unlike *gaujoni* and *peruvensis*. I have only seen the male types, but believe that the female of "*dognini*" belongs here.

E. gaujoni Dgn. Easily distinguished by the complete lack of ocelli, which are replaced by black-edged transverse bands, conspicuous in the female, but only faintly seen on the transparent wing of the male. The lateral stripe of the thorax is absent; and the abdomen mainly black.

E. peruvensis Hamps. At first glance this species looks like a mere race of *scribonia*, especially the specimens in which the abdomen is blue. The typical ones with gray abdomen are more distinct; the antenna is simple (perhaps showing some slight serration at the apex), and the lateral stripe on the thorax is reduced to a few dark hairs behind the eye. The blue fore coxæ and front, used as a character by Hampson, fail in series, as in most species of this genus; the pink tint, also specified by Hampson, is more noticeable in *burmeisteri* and *kinkelini*, where it may be very bright. There are specimens from Paraná with the fore wing practically fully scaled, and merely a dot on the inner margin of the hind wing, which may be a race of this species.

E. ganglio Obt. This species looks startlingly like an undersized specimen of *orsa*, but entirely lacks the secondary sexual characters. Of the two specimens I have seen, one has lost the marginal marking of the hind wing, and the other the mark at the end of the cell. The abdominal pattern, with a tendency to cut off orange subdorsal dots, reappears in *orsa* forms.

In the following species the thorax is unlike most Ecpantherias in having a simple fine black loop on each tegula, while in general the loop is constricted, or divided into two ocelli; on the other hand, unlike the *mus* group, the collar has regular ocelli.

E. obsolescens Hmps. If this is correctly identified in the U. S. National Museum, Hampson's figure of the male was based on a deformed specimen with exaggerated anal lobe. Otherwise they agree.

E. testacea Roth. I have seen nothing like this, which must be extremely close to *obsolescens*.

E. cretacea Dgn. Quite a distinct species, and the smallest and most lightly marked of the normal group. The relationship is plainly to *obsolescens*, and a little more distantly to *peruvensis*.

E. burmeisteri Roth. The small size and rather large gray-filled ocelli which show a tendency to fuse, give this species quite a marked resemblance to *detecta* and *aramis;* but the regular series of middorsal salmon (orange) spots is immediately distinctive, *aramis* having a continuous stripe and detecta a gray median region. One specimen in the National Museum (somewhat suffused in pattern) has the abdomen orange instead of salmon, and may be either an aberration or a faded specimen. The thoracic spots are less noticeably dark filled than in *aramis*, with which Dognin confused the species.

E. kinkelini Burm. (*aramis* Obt.). Easily distinguished by the *continuous* middorsal stripe, which is short in *kinkelini*, but reaches the end of the abdomen in *aramis*. It seems still uncertain if these are local forms or sexes.

Group indecisa. In this group the anal lobing of the hind wing nearly disappears but not quite. Sexual dimorphism in coloring seems common, and in *obtecta* is extreme. In the female the abdomen seems always to have a conspicuous series of middorsal orange spots, which are less a feature of the male. There is a tendency in all the species to develop a slight claw on the fore tibia, which becomes very large in the species described below. I have not seen *anomala*, but it seems to belong here. *Obtecta* is distinguished from most of the rest of the genus by the immaculate dark fore tibia.

E. chelifer new species.

Superficially similar to *indecisa*. Fore wing darker (male), the gray filling of the ocelli less contrasting; hind wing immaculate (type) or with some obscurely ocellate terminal spots at apex (Buenos Aires), or with an anal spot, and the fringe black from Cu_2 to 2d A. Costa of hind wing beneath bright ochre yellow, contrasting (as in the female

of *obtecta*, but unlike *indecisa*). Fore tibia much less than half as long as tarsus, dark gray, with a lighter gray band across its middle, edged with cream white lines and broad black bars, unlike the simpler cream and black barring of *indecisa*. A massive inner claw, a third as long as the tibia, and a smaller outer claw.

Type male from Tintina, Santiago d'Estero, Argentina, Feb. 21, 1920, and paratype from Buenos Aires, received as *E. indecisa*. Also a paratype from Tucuman (P. Girard, Dognin coll.) in the U. S. National Museum. It is possible this may be the form noted as ab. 1 of *indecisa* by Hampson, which Strand christened *indecisana*, apparently without seeing a single specimen; but *indecisa* does in fact vary considerably in ground color, and Hampson makes no note of the characteristic structure or color of the under side. Mr. Tams of the British Museum writes me that Hampson did not label his unnamed aberrations, and that therefore the "type" of indecisana is not to be identified. The leg of this species is obviously fossorial, and leads one to suppose there is something special in the life history.

E. obtecta Dgn. Sexual dimorphism in this species is striking, but both sexes have the plain brown fore tibia, unlike *indecisa* and *chelifer*. I accept the identification from Dr. Schaus, who has based it on the hermaphrodite collected by Jorgensen (Revista Soc. Cien. Paraguay, i, 90.) of which there is a colored figure in the National Museum.

Group atra. I will not pretend to say how many real species there are in this group, but suspect there are less than the four I list. All are Central American, and I have only seen material in the National Museum. They are representatives of the *læta* group, also mainly from Central America, but wholly lack the anal lobe; the presence of middorsal abdominal black spots in the only case where the black is so restricted as to make it possible to tell (male *andromela*) indicates a connection with *suffusa*, rather than *obtecta*, which some of the males resemble at first glance.

Group suffusa. *Suffusa* and *confusa* seem to intergrade in the U. S. National Museum, though typical specimens are different enough. The only other species which may belong here is *oslari*, which I have not seen.

LIST OF SPECIES, WITH CITATION OF THE MOST IMPORTANT PUBLISHED FIGURES.

Obt.—Oberthür: Etudes d'Entomologie, fascicule vi.
H—Hampson: Catalogue of the Lepidoptera Phalænæ, vol. iii.
Hs—Hampson's Catalogue, Supplement, vol. ii.
S—Seitz: Macrolepidoptera of the World, vol. vi. (The figures on each line of the plates are numbered from the left).

Group A.

1. *albicornis Grote, Proc. Ent. Soc. Phil., v. 4: 4.

Group B.

2. *eridanus Cramer, 68 G.
   syn. (ab.?) *eridane* Hbn. Samml. Exot. Schm. i, pl. 191 (Kirby's numbering).
3. icasia Cramer 181 E; S 41 a5 ♂, b1 ♀.
   a. *i. icasia Cr. (West Indies).
      syn. *lantanæ* F.
      obliterata Wlk. (Nevis).
      simplex Wlk. (Nevis).
      eridanus Seitz, pp. 473, nec. Cr.
      ab. ♂ guadulpensis Obt. 13:2 (Guadeloupe).
   b. *i. trinitatis Rothschild (Trinidad to Peru).
   c. *i. muzina Obt. 12: 4; S 41 a2 (poor of ♂), 3♀, (Colombia, etc.).
      eridanus Obt. 12: 1; S 41 b3, nec Cr.
      ? *caudata* Wlk. (has priority if correct).
      ♂ *thimei* Obt. 12: 6 (dwarf).
      ♀ *depauperata* Obt. 12: 8.
      ♀ *abscondens* Obt. 12: 7.
      ♀ *garzoni* Obt. 13: 3.
      ♀ *xanthenota* Obt. 13:6.
   d. †i. mexicana Obt. 15: 1♂ (3♀?), (Mexico, U. S.?).
      ab. trans. †yukatanensis Obt. 13: 4.
   e. i. albicollis Obt. 12: 5 (? if distinct, not seen), (Brazil).
4. mus Obt. 16: 1; S 41 b4.
   a. †m. mus Obt.
      ♀ *bahiaensis* Obt. 16: 5; S 40 h4.
      ♀ *boisduvalli* Obt. 16: 6.
   b. †m. castronis Strand.
      brasiliensis (*braziliensis*) Roth., nec Obt. Hs 62: 13, 14.
5. †heterogena Obt. 15: 2; S 40 h3 ♀.
      pellucida Schs. Am. Lep. 3: 11, 12.
      ♀ *contexta* Obt. 16: 2.
6. kennedyi Rothschild Hs 63: 1 ♂.

Group C.

7. †bolivar Obt. 13: 1.
8. scribonia Stoll, Cr's Suppl. 41: 3; Hbn. 403; Obt. 17: 5; etc.
   a. *s. scribonia Stoll.
      ocularia auct., possibly of F.
      oculatissima A. & S. Pl. 69.
      deflorata Hamp., nec F. S 40 g1 ♂, 2 ♀.
      cunegunda Beauv., (not cunigunda Stoll).
      chryseis Oliv.
      ab. ♂ denudata Slosson.
      ab. ♂ confluens Obt. 17: 3; S 40 g3 (*trans.).
   b. †s. columbina Obt. 16: 3 ♂ (4, 7 ♀ ?).
   c. s. quitensis Obt. 17: 1, 2; S 40 f5 ♀.

9. ocularia auct. (F.?) S 40 g5 ♂, 4 ♀.
   a. *o. ocularia auct.
      cyaneator Wlk.
      ? *columbina* Obt. 16: 4, 7 ♀.
      ab. distans Obt. 17: 6 (possibly to form robusta).
   b. †o. robusta Dognin Lep. Loja 4: 10 ♂.

Group D.

10. †persola Moschler, S 41 c3 ♀.
11. †cotyora Druce, Biologia Centrali-Americana 10: 4, 5; S 40 f2 (pale male), 3 ♀.
12. †leucarctioides Grote and Robinson, S 40 e5 ♂, 6 ♀.
      ab. tenella H. Edwards.
      trebula Druce.
13. †læta Walker, H p. 369; S 40 e2 ♂.
14. †præclara Obt. 19: 1; S 40 e3 ♂.
      ab. theophila Dognin.
15. †brasiliensis Oberthur 19: 2, 3, 6; S 40 e4 ♂.
      braziliensis Hamp.
      ? *nigriloba* Hulstaert, Ann. Soc. Ent. Belge, lxiv, 106, 1924 (Petropolis, Rio, Brazil).
16. †magdalenæ Obt. 18: 5, 8; S 40 e1 ♂, d6 ♀.
      ab. steinbachi Roth.
17. ochreator Felder 101: 2; S 40 f1 ♀.
   a. †o. ochreator Fld.
   b. †o. euripides Dyar, Hs 63: 2; S 67 e4 (as eurypides).

Group E.

18. †nigriplaga Walker, H 47: 13; S 41 b5.
19. orsa Cramer 143: F.
   a. o. orsa Cr. (Northern South America).
      cayennensis Obt. 14: 1 ♂, 3 ♀.
      decipiens Obt. 15: 6 ♀.
      bari Obt. 14: 5 ♀; S 40 i1.
      dubiosa Obt. 14: 6 ♀.
      *normal male cunigunda Stoll in Cr. 344 D, E; S 40 h2.
   b. †o. alpha Obt. 14: 2 ♂; S 40 i5 (Mexico and Central America).
      orbiculata Dr. nec. Obt.
      decora Dr. nec Wlk.
   c. †o. perplexa Schs. Hs. 63: 3; S 67 e6 (Costa Rica).
   d. *o. abdominalis Walker, S 40 i2 ♂ (Brazil).
      orbiculata Obt. 14: 7 ♀.
      proxima Obt. 15: 9 ♀.
      annexa Obt. 14: 4 ♂.
   e. †o. decora Walker S 40 h5 ♂, 6 ♀.
      cyaneicornis Grote.
      haitensis Obt. 15: 5, 7.

Group F.

20. detecta Oberthur 15: 8.
   a. d. detecta Obt. (Para).
   b. d. detectiva Obt. 17: 4; S 40 i3 (no locality).
   c. d. dognini Roth. Hs 63: 5 ♂ (not 6); S 67 f3 (S. Brazil).
   d. *d. dorsata new race (Matto Grosso).
21. †jaguarina Schaus, Ins. Ins. Men. 1921, p. 170.
      ? *dognini* Roth. (female, not male), Hs 63: 6; S 67 f4.
22. †gaujoni Dognin Lep. Loja 4: 11, 12.
      ? *oculatissima* var. Obt. (from Brazil).
23. †peruvensis Hampson, H 51: 10; S 41 b2 ♂.
24. †ganglio Obt. 13: 5.

25. †obsolescens Hampson, Hs 63: 9, 10.
26. testacea Roth., Hs 63: 7, 8.
27. †cretacea Dognin, Hs 63: 11, 12; S 67 f1 ♂, 2 ♀.
28. †burmeisteri Roth. Nov. Zool. xviii 3: 23, 24; S 41 c2 ♂, 1 ♀.
29. †kinkelini Burmeister, Obt. 18: 1, 6; S 41 a4.
    a. k. kinkelini Burm. (Argentine).
    b. k. aramis Obt. 18: 2, 3; S 40 i4, (Brazil).

Group G.

30. *indecisa Walker, Obt. 18: 4, 7; S 40 d1 ♂, 2 ♀.
    degenera Wlk.
    annulifascia Wlk.
    ab. indecisana Strand.
31. †obtecta Dognin, S 67 e7 ♂.
    ♀ *flavopunctata* Schs.
    ? ab. ♂ melanoleuca Roth. Nov. Zool. xviii 3: 17; S 41 a1.
32. †albiscripta Druce, H 47: 6; S 40 d3.
33. anomala Burmeister.

Group H.

34. *chelifer, new species.
    indecisa auct. in part (possibly S 40 d1 ♂, 2 ♀),
    possibly *indecisana* Strand.

Group I.

35. †confusa Druce, Biologia 75: 7.
36. *suffusa Schaus, Biologia 75: 11; S 40 d4 ♂, 5 ♀. (possibly a var. of confusa).
37. oslari Roth. Nov. Zool. xviii 3: 29; S 41 b6.
    ? *semiclara* Stretch.

Group J.

38. †amulaensis Dr. Biologia 75: 4; S 67 g1 ♂, f5 ♀.
    ab. amula Strand.
39. †extrema Walker, S 40 f4.
    chilensis Obt. 20: 5.
40. †andromela Dyar, Hs 63: 13, 14; S 40 c6 ♂.
41. †atra Obt. 15: 4; S 40 c7 ♂.
    ab. eminens H. Edwards.

THE COMPARATIVE MORPHOLOGY OF THE SPIRACLES OF TWO SPECIES OF WEEVILS.

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The subjects of this study were the granary weevil (*Sitophilus granarius* Linn.) and the corn billbug (*Sphenophorus maidis* Chitt.).

Although the granary weevil is well known as a mill pest, the morphology of the species has not been extensively studied. This has probably been partly due to the fact that the adult insect is only 2 to 3 mm. in length. The corn billbug is from 2 to 3 cm. in length.

Both species have five pairs of abdominal spiracles lying in the pleural coria just above the hard sternum. It was this group of spiracles that was studied. The granary weevil appears to have a pair of thoracic spiracles, but these are very difficult to isolate.

A special technique was required for the dissection of the granary weevil. The beetles were mounted in a paraffin block and dissected under 50% alcohol with the aid of a binocular magnifier. The entire abdominal dorsum was removed, passed through graded alcohols, and mounted on a slide. In some cases the tissues were stained with Ehrlich's haematoxylin; in others the soft parts were removed with sodium hydroxide. Sections were also made of the whole abdomen. These were cut 30 μ thick from paraffin and stained with iron-haematoxylin and lichtgrun.

The spiracles of the billbug could be easily dissected out under the binocular. Some were studied under the magnifier; others were mounted on slides and examined microscopically.

By referring to Figure 1, one can study the characters of spiracular structure in the granary weevil. Beyond the spiracle proper (S) is a chamber (A), leading to a chitinous bow (B). Just beyond this bow the trachea is constricted somewhat, but at once widens to form a kind of vestibule (V). There are two tracheal trunks (T and T_1) communicating with the vestibule. No muscles are attached to any part of this apparatus.

No evidence of spiracular closing could be found in either living or dead specimens.

The spiracles of the billbug differ strikingly from those of the granary weevil. In addition to the heart-shaped spiracular opening, there is a true atrium continuous with a pair of triangular chitinous plates (B and B_1; Figures 2, 3, and 4). Between these plates is a slit (O) communicating with the large air chambers so conspicuous in the body of this species. This slit, normally closed, is opened by the contraction of a band of

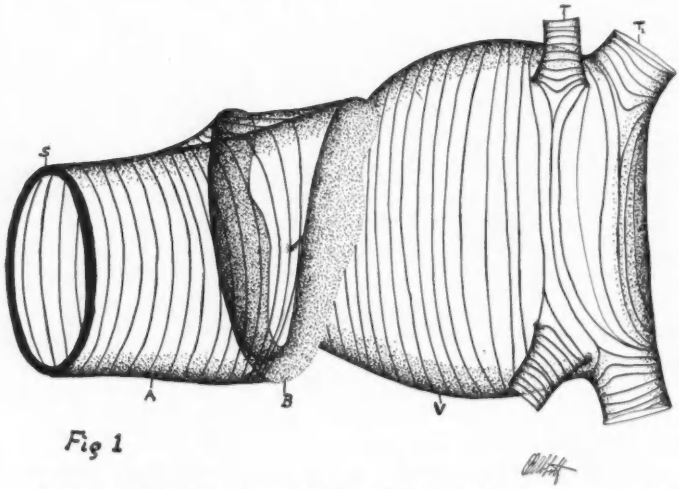


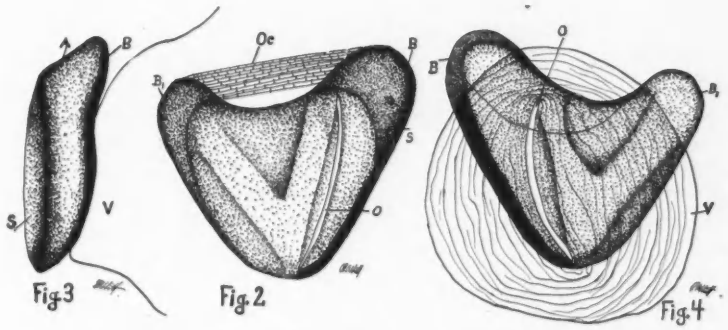
Figure 1. Spiracle and associated structures of the granary weevil. S, spiracle; A, trachea between spiracle and bow; B, chitinous bow; V, vesicle or inner chamber; T and T^1, the dorsal and ventral branches of the principal tracheal trunk.

muscles (Oc.) connecting the divergent apices of the triangular plates. Figures 2 and 3 represent the outer and side aspects respectively of this mechanism. Figure 4 represents a view from the interior of the insect body toward the spiracle. The air chamber (V) is united to the margins of the slit between the two plates.

The margin of the plate B is darker in color than the remaining portion, and is probably highly chitinized. The central portions of plate B_1 are elevated above the remaining portions, and are darker in color.

These drawings do not include the trident hairs that are found on the plates, and are longest along the margin of the slit, across which they interlace.

I am at a loss to explain the presence of the chitinous bow found near the spiracle of the granary weevil. Inasmuch as the whole tracheal system of this species is quite rigid, the presence of an occluding apparatus seems unnecessary. Indeed, as Krogh (1920) has stated, such a system indicates a type of respiration mostly dependent upon diffusion.



Figures 2, 3 and 4. Spiracle and associated structures of the corn billbug. S, spiracle; B and B¹, chitinous plates; O, slit between plates; V, air chamber; Oc, occlusor muscle; A, atrium.

The nature of the tracheal system lying between the spiracle proper and the bow is also an enigma. Its position suggests an atrium, but it differs from a true atrium in various ways, especially in having tenidia. Imms (1924) states that the atrium regularly "lacks tenidia" (p. 106). Either this case is an exception to Imms' claim, or what seems more probable, the atrium has disappeared. It is also significant that the trachea of the granary weevil is constricted near the chitinous bow, just as the air chamber of the billbug narrows to communicate with the slit between the two plates.

That the granary weevil is in a state of degeneration is demonstrated by its lack of metathoracic wings. May not the spiracular occluding apparatus be in a state of degeneration from the more primitive type found in the billbug?

In conclusion I wish to express my appreciation to Dr. R. H. Painter, Dr. R. L. Parker, and Dr. R. C. Smith, all of the Kansas State Agricultural College, for aid in this and related problems.

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ENTOMOLOGICAL SENTIMENT.

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To be called a sentimentalist does not always carry distinction. Neither does it in any manner describe the individual referred to. Sentiment is to most of us a vague term denoting something of special meaning to each. However, in the main, we all think of it as somewhat beneath the dignity of mature masculinity. It is defined in many ways, but in my brief discussion I am thinking of this definition, i. e., a decision of the mind formed by thought, deliberation and reasoning. Recognizing this meaning as such, is there a place in the study of entomology for sentiment? It is to be supposed that the older members of our profession who have maturity, experience and historical background are the ones most likely to approach feelings of this sort, while the rest of us can only hope to acquire the same by continuous, energetic study.

As a professional science, entomology is comparatively young in this country. In fact it is less than one hundred years old. And these few years have been crowded to the brim with so much energy, determination and accomplishment that there has been little time for anything excepting the immediate demands. Occasionally, we pause to look back at the landmarks in the distance and attempt to evaluate the lives and contributions of the outstanding men in this science. Only by so doing can we hope to create and develop a professional consciousness, which I choose to call sentiment.

As a prelude to the more serious aspects of our program this year there are several papers devoted to retrospect of this sort.

In our associations with our living brethren we are not likely to exchange sentimentalities. Most of us do have some feeling and reverence for our teachers and the older entomologists whom we have learned to admire without any ideas of suspicion or jealousy. But here, also, we are likely to find that what few real sentiments we do possess are not shared in common by our associates.

It is perfectly obvious, therefore, that to get anywhere in the discussion of this topic I must turn back the pages of time and look into the past for the subject material which I wish to place before you who are gathered here today. No single thing has given me a greater amount of real pleasure than the study of the history and development of entomology in this country.

As a starting point we might first think of John Bartram (1699–1777), the first American to publish notes on insect life.[1]

With a knowledge of Bartram's activities in the botanical field, his connection with the American Philosophical Society, with Benjamin Franklin, Thomas Jefferson, and other patriots, and his timely contributions in entomology, one cannot visit the stone house wrought by his own hands and the quaint little garden on the banks of the Schuylkill River in Philadelphia, without a feeling of profound respect. Yet how many entomologists visiting this historic city have paid homage to Bartram's shrine?

Or if more precise, we might begin with Frederick V. Melsheimer (1749–1814), generally considered to be the founder of American Entomology. Who can read Hagen's[2] admirable account of him without a genuine thrill of pride in this early pioneer in a field then so new as to be practically unknown.

Thomas Say (1787–1834), the father of American Entomology, needs no advocate. His resting place at New Harmony, Indiana, has been made sacred to all entomologists by the pen of the late F. M. Webster, in a series of articles in Entomological News.[3] Although his grave is marked by a monument,[4] it was not erected by an admiring public or by followers of the profession which he did much to establish. One can neither read nor write the scientific names of many of our most important American insects without recalling the early endeavors and hardships of this great naturalist. The grape leafhopper, box elder bug, chinch bug, ashy-gray ladybird beetle, Colorado

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[1]An account of some very curious wasps' nests made of clay in Pennsylvania. Philos. Trans. (London), 43, No. 476, pp. 363–6, Figs. (Read by P. Collinson, April 25, 1745).

[2]Hagen, H. A. Can. Entom., Vol. 16, pp. 191–197, (1884).

[3]Vol. 6, pp. 1–4, 33–34, 80–81, 101–103, pls. 1, 2, 4, 5, (1895).

[4]This monument of white marble was erected in 1846 by Alexander Maclure, brother of William Maclure, and is situated behind the Maclure residence in which Say died on October 10, 1834. Entom. News, Vol. 6, p. 101, (1895).

potato beetle, bean weevil, woodland malaria mosquito, Hessian fly, peach tree borer, odorous ant, common tarantula hawk, and many other outstanding insects named by him, testify to the importance of his contribution to entomology. I hope that in the not far distant future, the entomologists from all over this continent will organize a great pilgrimage to his tomb as an expression of the respect and high regard to which he is entitled, as well as a means of making it one of the historic spots in America. We, more than any other scientists, should lead the way to his grave.

The tendency to exclusive specialization among entomologists is gradually, I think, giving way to the realization that, after all, a sound training necessitates an understanding of many particular fields. Whether this is true or not, all appreciate the value and place of specialization in both systematic and economic studies. Such a society as this co-ordinates and promotes a unity of endeavor and feeling among all specialists and breaks down the barriers of class exclusiveness.

Insofar as my presentation is concerned, it makes no great difference whether this idea regarding particular subjects is accepted or not. One can find enough in every specialty to stimulate feelings of genuine sentiment. But the wider the individual horizon the more there is to be found in the lives and works of his predecessors.

Among the pioneers, William D. Peck and Thaddeus William Harris, of Massachusetts, and Asa Fitch, of New York, truly led the way. What they meant to those who followed may be illustrated by the words of Prof. J. H. Comstock at the Toronto Meeting in 1922.[5] After a small laboratory had been established for him at Cornell, he states, "I was very anxious to learn how to do my work. Up to the time I was made instructor in entomology (1867), I had no assistance whatever in entomology. So I made a pilgrimage to Salem, New York, to visit Dr. Fitch. That stands out as one of the bright memories of my experience." It is to be remembered that the pioneers had no such opportunities to seek advice. Peck became interested and instructed in entomology by the help of a copy of Linnaeus' Systema Naturæ taken from a shipwreck near his home on the coast of New Hampshire.

[5]Jour. Econ. Entom., Vol. 15, p. 33, (1922).

The pioneers were followed by the great constructionists, H. A. Hagen, S. H. Scudder, A. S. Packard, B. D. Walsh, Henry Skinner, S. W. Williston, E. T. Cresson, C. J. S. Bethune, J. L. LeConte, Geo. H. Horn, H. H. Behr, Henry Edwards, and many others. The only monuments left to their memory are those made by themselves, namely, their published works and their collections. While all of us are cognizant of the worth of their writings, few of us hardly appreciate the value of their collections! Fortunately some of our museum specialists do and it is to be hoped that the same care and vigilance long kept by Samuel Henshaw of the Cambridge Museum will be emulated in all museums in the present and future. In this relation I recall the significant words of Geo. H. Horn in connection with his visits to the LeConte collection at Cambridge: "Annually (since taking the LeConte collection to Cambridge) I have made one or two visits for the more accurate study of its types after a thorough study of my own material had been completed. In that collection I find not only the bare facts, for which I seek, but much besides. In the more than thirty years of our association there is not a box which has not been before us in the topic of discussion or for consultation. Every one recalls its memories, and even particular specimens recall incidents of interest. To me such a visit is, therefore, more than the comparison of specimens, it puts me in touch with a friend. . . . . I regret greatly that many of the traditions of the collection are known only to me."[6]

Until we are ready to build monuments of another kind in honor of these men who have gone before, we are charged to preserve their collections. This is now being done in all of our great museums which are destined to become the great and sacred entomological shrines, if not for us, for those who follow! With a knowledge of the lives and activities of these men we are in a position to get a great deal more from their collections. Some few years ago I visited a great museum and in common with most folks looked over the conspicuous displays on the main floors, never knowing or dreaming that in the attic was one of the most valuable insect collections in America. How many opportunities are thus lost by a lack of a knowledge of a historical or sentimental background! On this trip I revisited

[6]Entom. News, Vol. 7, pp. 49–50, (1896).

the same museum for the express purpose of retrieving the previous losses.

The early great teachers might be mentioned next: H. A. Hagen, C. H. Fernald, A. S. Packard, A. J. Cook, T. H. Comstock, Herbert Osborn, Lawrence Bruner, and many others. Their contributions of text books and trained students have exerted the greatest influence upon entomology as it is still being taught today. We may be rising a little higher and going a step further in our instruction, but we are still building upon the foundations laid by them.

The organization of economic entomology fell to the lot of T. W. Harris, Asa Fitch, B. D. Walsh, Townsend Glover, C. V. Riley, Cyrus Thomas, J. A. Lintner, C. H. Fernald, H. G. Hubbard, Otto Lugger, William Saunders, M. V. Slingerland, and a few others, who established here in our rapidly expanding country a type of work never dreamed possible, and still unrealized in most other countries. To these men we owe the establishment of entomology as a practical profession and they made the places which most of us occupy today. To Fletcher only has an outward sign of recognition been made. A memorial fountain was erected by his associates and fellow workers at the Experimental Farm, Ottawa, Canada, July 19, 1910.[7]

Perhaps the most lasting contributions were those made by the early great systematists who explored the unknown and brought order out of chaos and left us an inheritance of facts upon which all of our present fundamental knowledge is based. Thomas Say, H. A. Hagen, A. S. Packard, S. H. Scudder, E. T. Cresson, C. R. Osten Sacken, A. R. Grote, D. W. Coquillett, W. M. Ashmead, J. B. Smith, J. L. LeConte, Geo. H. Horn, T. L. Casey, P. H. Uhler, and a great many others, have each made more valuable contributions along this line than most of us can ever hope to accomplish. They had unique opportunities and they made the best of them!

Obituaries are notably lacking in information relative to the actual burial places of practically all of these notables and I wonder if all of their last resting places are known at the present time.

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[7]Can. Entom., Vol. 42, p. 265, pl. 7, (1910).

In so short and hasty a sketch it is only possible to indicate the background of our profession and to mention the fact that we have been endowed with a hard-earned heritage, the importance of which few of us realize. What are we to do about it? Do we owe anything to these benefactors? Have we any responsibilities excepting to use of their substances such as will enable us to make better livings for ourselves?

Dr. Howard more than any other living man in America has been most interested in this line of thought. He has kept us informed concerning the past. His stories and reminiscences have brightened many an entomological gathering and there has always been a keen interest and quick response to his contributions.

As a closing suggestion I have thought that it could be arranged by the different societies and associations to raise or set aside certain funds yearly for the sole purpose of placing suitable memorials at the resting places of some of these great leaders in entomology, as a recognition of their services to the world and to preserve that information for posterity. That there is not more sentiment in entomology is largely due to the fact that we have not yet aroused ourselves to the full responsibilities and privileges that are ours!